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NATIONAL DAM SAFETY PROGRAM. WINTER LAKE DAM (MO 30805) UPPER M--ETC(U)
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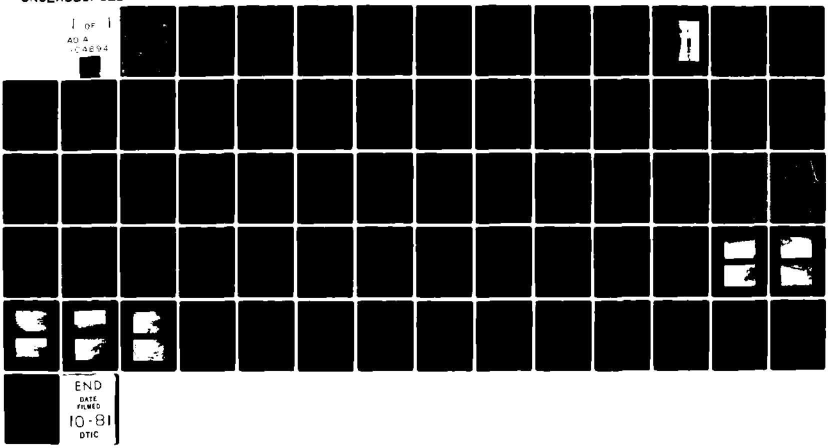

LEVEL II

UPPER MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

WINTER LAKE DAM

FRANKLIN COUNTY, MISSOURI

MO 30805

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

United States Army Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

OCTOBER 1980

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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UPPER MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

WINTER LAKE DAM

FRANKLIN COUNTY, MISSOURI

MO 30805

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

OCTOBER 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

LMSED-P

SUBJECT: Winter Lake Dam, MO 30805, Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Winter Lake Dam (MO 30805):

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following cirteria:

1) The combined capacity of the spillways will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

2) Overtopping of the dam could result in failure of the dam.

3) Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — 12 DEC 1980
Chief, Engineering Division — Date

APPROVED BY: SIGNED — 15 DEC 1980
Colonel, CE, District Engineer — Date

WINTER LAKE DAM

MISSOURI INVENTORY NO. 30805

FRANKLIN COUNTY, MISSOURI

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

CORPS OF ENGINEERS

OCTOBER 1980

HS-8011

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Winter Lake Dam
State Located:	Missouri
County Located:	Franklin
Stream:	Tributary of Bourbeuse River
Date of Inspection:	28 August 1980

The Winter Lake Dam was visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of this inspection was to assess the general condition of the dam with respect to safety, and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

The following summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the visual inspection and the results of these hydrologic/hydraulic investigations, the present general condition of the dam is considered to be somewhat less than satisfactory. The following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam:

1. A dense growth of brush and small-to-medium size trees were present along the berm on the upstream face of the dam. Small trees were also found on the downstream face of the dam. Tree roots can provide passageways for lake seepage which could lead to a piping condition (progressive internal erosion) that can result in failure of the dam. Brush may conceal animal burrows which could also provide passageways for lake seepage.

2. The last 3 feet, or so, of the outlet pipe for the principal spillway is without support. A pool of water, approximately 15 feet wide by 30 feet

long and 2 feet deep, exists just downstream of the end of the outlet pipe. The pool appears to have been created by pipe discharges scouring a depression in the bottom of the spillway outlet channel adjacent to the dam. However, the outlet facility may have been designed (constructed) as a plunge pool type energy dissipator utilizing a cantilevered outlet pipe. Since the pipe does not project beyond the toe of the dam, erosion of the area adjacent to the dam by pipe outflow can occur. Loss of material at the toe of the embankment can impair the stability of the dam; saturation of the soil adjacent to the embankment by standing water can weaken the strength of the material and reduce its capacity to provide foundation support which could also be detrimental to the dam's stability.

3. At the time of the inspection, the grass on the dam was approximately 3 feet high. Grass should not be allowed to reach a height that will provide cover for burrowing animals or hinder inspection of the dam. A hole believed to be an animal burrow was found in the upstream slope of the dam at the location of the drop inlet spillway.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Winter Lake Dam, which is classified as intermediate in size and of high hazard potential, is specified to be the Probable Maximum Flood (PMF). The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Results of a hydrologic/hydraulic analysis indicated that both spillways, principal plus emergency, are inadequate to pass lake outflow resulting from a storm of PMF magnitude without overtopping the dam. The spillways are capable of passing lake outflow resulting from the one percent chance (100-year frequency) flood and the outflow corresponding to about 40 percent of the PMF. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be one mile. Accordingly, within the possible damage zone are a railroad crossing and four dwellings.

A review of available data did not disclose that seepage or stability analyses of the dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action in the near future to correct or control the deficiencies and safety defects reported herein.

Harold B. Lockett

Harold B. Lockett
P. E. Missouri E-4189

Albert B. Becker, Jr.

Albert B. Becker, Jr.
P. E. Missouri E-9168

OVERVIEW WINTER LAKE DAM

PHASE 1 INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

WINTER LAKE DAM - MO 30805

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

WINTER LAKE DAM - MO 30805

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Winter Lake Dam be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the above dam with respect to safety and, based upon available data and this inspection, determine if the dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams", Appendix D to "Report to the Chief of Engineers on the National Program of Inspection of Non-Federal Dams", dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Winter Lake Dam is an earthfill type embankment rising approximately 46 feet above the natural streambed at the downstream toe of the barrier. A wave berm about 20 feet wide is located in the upstream face of the dam at a point approximately 10 feet below the dam crest. The upstream slope of the embankment (above the waterline) varies from about 1v on 2.0h to 1v on 2.5h between the crest and the berm, and from approximately 1v on 3.0h to 1v on 2.1h between the wave berm and the observed waterline. The crest of the embankment is about 16 feet wide, and the downstream face has a slope on the order of 1v on 2.4h. The length of the dam is approximately 553 feet. A plan of the dam is shown on Plate 3, a profile of the dam crest on Plate 4, and a cross-section of the dam on Plate 5. At normal pool elevation, the reservoir impounded by the dam occupies approximately 23 acres. The dam has no drawdown facility to unwater the lake. An overview photo of the Winter Lake Dam is shown following the preface at the beginning of the report.

The dam has both a principal and emergency spillway. The principal spillway, which is located near the center of the dam, consists of a 42-inch diameter steel drop inlet riser with an anti-vortex plate and a 30-inch diameter steel outlet pipe. A trash rack fabricated of steel reinforcing bars surrounds the intake area above the inlet to protect the spillway from clogging. The spillway outlet pipe discharges to the original stream channel at the toe of the dam. A profile of the principal spillway is superimposed on the dam cross-section on Plate 5.

The emergency spillway is located at the left, or east, abutment. The spillway outlet channel, an excavated earth trapezoidal section, is cut into the hillside with an earth bank constructed on the downhill, or right, side to confine flow to the channel. The channel, which extends approximately 90 feet downstream of the centerline of the dam, discharges to a natural drainage swale located just downstream of the dam at the left abutment. A profile of the emergency spillway is shown on Plate 4, and a cross-section of the spillway channel at the crest location is also shown on Plate 4.

b. Location. The dam is located about 0.3 mile west of Hilltop Road on an unnamed tributary of the Bourbeuse River, about 1.0 mile northwest of the intersection of State Highway M and Interstate Highway I-44 and approximately 2.3 miles southwest of the Town of Villa Ridge, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in Section 21, Township 43 North, Range 1 East, within Franklin County.

c. Size Classification. The size classification based on the height of the dam and storage capacity, is categorized as intermediate (per Table 1, Recommended Guidelines for Safety Inspection of Dams).

d. Hazard Classification. The Winter Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there may be loss of life, serious damage to homes, or extensive damage to agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District, extends one mile downstream of the dam. Within the possible damage zone are a railroad crossing and four dwellings. Those features lying within the downstream damage zone as reported by the St. Louis District, Corps of Engineers, were verified by the inspection team.

e. Ownership. The Owners of the dam and their addresses are as follows:

Dr. John H. Winter, 12205 Blackheath Court, St. Louis, MO 63141
Dr. Paul N. Meiners, #2 Country Aire, St. Louis, MO 63131
Dr. Joseph J. Lauber, 39 Villa Coublay, St. Louis, MO 63141

Dr. Winter acted as spokesman for the group during the course of the investigations presented herein.

f. Purpose of Dam. The dam impounds water for recreational use.

g. Design and Construction History. According to Dr. Winter, one of the Owners, the dam was constructed in 1969 by the Gregg Williams Excavating Company of O'Fallon, Missouri. At the request of Dr. Winter, a preliminary geologic investigation of the proposed dam site was made on November 4, 1968, by Neul F. Edmonds, a geologist with the U. S. Department of Agriculture, Soil Conservation Service, State Office, Columbia, Missouri. A copy of Mr. Edmonds' report, reference charts 2-1 and 2-2, is included herewith. Dr. Winter reported that the Soil Conservation Service (SCS) also designed the dam; however, no record of the SCS design could be found. According to Mr. William Shottwell, District Conservationist with SCS at the time the dam was constructed and now retired, the area SCS office did design the dam. However, no records of the design were available with SCS, and it was reported by Mr. Jack Schneider, Area Engineer, that it was SCS policy at that time to dispose of all records of their designs once five years elapsed. A letter provided by Dr. Winter, reference chart 2-3, written by Warren W. Pflantz, SCS Area Engineer, dated August 7, 1969, also confirms that SCS designed the dam, since the contents of the letter indicate that several additional items are required to meet our (SCS) specifications, and a copy of these specifications is included with the letter.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the combined capacities of the drop inlet type principal spillway and the excavated earth type emergency spillway.

1.3 PERTINENT DATA

a. Drainage Area. With the exception of the valley along the southeast trending tributary to the lake, which is under cultivation, the area tributary to the lake is essentially in a native state covered with timber. The watershed above the dam amounts to approximately 750 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum flood at damsite ... 205 cfs*(W.S.Elev. 525.4)
(2) Spillway capacity
  a. Principal ... 83 cfs (W.S.Elev. 524.4)
  b. Principal + emergency ... 2,773 cfs (W.S.Elev. 530.4)

c. Elevation (Ft. above MSL). The following elevations were determined by survey and are based on topographic data shown on the 1969 Moselle, Missouri, Quadrangle Map, 7.5 Minute Series.

(1) Observed pool ... 512.5
(2) Normal pool ... 520.0

*Based on an estimate of depth of flow at emergency spillway as observed by Mr. Louis Sieve, Caretaker.

(3) Spillway crest

a. Principal ... 520.0

b. Emergency ... 524.4

(4) Maximum experienced pool ... 525.4*

(5) Top of dam ... 530.4 (Min.)

(6) Streambed at centerline of dam ... 488± (Est.)

(7) Maximum tailwater ... Unknown

(8) Observed tailwater ... None

d. Reservoir.

(1) Length at normal pool (Elev. 520.0) ... 2,300 ft.

(2) Length at maximum pool (Elev. 530.4) ... 3,000 ft.

e. Storage.

(1) Normal pool ... 238 ac. ft.

(2) Top of dam (incremental) ... 294 ac. ft.

f. Reservoir Surface.

(1) Normal pool ... 23 acres

(2) Top of dam (incremental) ... 11 acres

g. Dam. The height of the dam is defined to be the overall vertical distance from the lowest point of foundation surface at the downstream toe of the barrier, to the top of the dam.

(1) Type ... Earthfill

(2) Length ... 553 ft.

(3) Height ... 46 ft.

(4) Top width ... 16 ft.

*Based on an estimate of depth of flow at emergency spillway as observed by Mr. Louis Sieve, Caretaker.

(5) Side slopes

a. Upstream ... 1v on 2.0h; 1v on 2.5h (above wave berm)
1v on 3.0h; 1v on 2.1h (below wave berm)

b. Downstream ... 1v on 2.4h

(6) Cutoff ... Core trench*

(7) Slope protection

a. Upstream ... Stone riprap, wave berm (elevation 520.0±)

b. Downstream ... Grass

h. Principal Spillway.

(1) Type ... Uncontrolled, drop inlet, 42-inch diameter steel riser

(2) Location ... Center of dam

(3) Crest elevation ... 520.0

(4) Outlet ... 30-inch diameter steel pipe

(5) Discharge elevation ... 490.9

i. Emergency Spillway.

(1) Type ... Uncontrolled, excavated earth, trapezoidal section

(2) Location ... Left abutment

(3) Crest elevation ... 524.4

(4) Approach channel ... Lake

(5) Outlet channel ... Natural drainage swale

j. Lake Drawdown Facility ... None

*Per Owner

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

A preliminary geologic investigation of the dam site, reference charts 2-1 and 2-2, was made in 1968 by Nuel F. Edmonds, a geologist with the Soil Conservation Service. In the report, which is dated November 4, 1968, Mr. Edmonds describes generally the materials found at the abutments and in the valley at the proposed dam location. The report also states that no faults were noted at the site, but that the general locality is an area of known faulting. (This statement conflicts with that of Jerry Higgins, Engineering Geologist for Horner & Shifrin, since according to data available to Mr. Higgins, no faults have been reported in the vicinity of the dam, reference Section 3.1b. It is possible that Mr. Edmonds had access to a more detailed study of the area, which was not made available for general use.) Mr. Edmonds states that some seepage in the sandstone may be expected, but that it is not expected to be a serious hazard. In the summary on the second page of the report, it is mentioned that based on surface investigations, the site is suitable; however, subsurface investigations are recommended. Mr. Edmonds recommends that the rock at the right abutment should be cored and pressure tested, that at least one hole be drilled in the channel, and one other hole be drilled on the flood plain. It is also recommended that the depth of the overburden on the flood plain, the left abutment, and the emergency spillway location, be determined.

Dr. Winter reported that the dam was designed by the Soil Conservation Service (SCS), and William Shottwell, District Conservationist with SCS at the time the dam was constructed and now retired, confirmed this. According to Mr. Shottwell, the design specified the dam crest width, the embankment side slopes, the proportions of the core trench, and the sizes of the spillways. Although Dr. Winter recalled seeing a blueprint of the dam, he was unable to locate a copy of the drawing. A search of both the SCS local and area office files also proved futile, and except for a letter, reference chart 2-3, written by Warren W. Pflantz, SCS Area Engineer, to Dr. Winter, no records of the design are known to exist. According to Dr. Winter, the additional anti-seepage collars and the wood pier support for the outlet end of the pipe specified in the letter by Mr. Pflantz, were not provided.

2.2 CONSTRUCTION

As previously stated, the dam was constructed in 1969 by the Gregg Williams Excavating Company of O'Fallon, Missouri. The present whereabouts of Mr. Williams is unknown, and the only record pertaining to the construction of the dam is a copy of an engineering geology report, reference chart 2-4, prepared by John W. Whitfield, an engineering geologist with the Missouri Geological Survey.

In the report, which is dated August 5, 1969, Mr. Whitfield states that he inspected the core trench of the dam when it was under construction, and that two springs existed within the trench, one at the base of the west (right) abutment, and the other in the central portion of the trench approximately 200 feet east of the west abutment. The egress locations of both springs were considered to be a layer of soft Roubidoux formation sandstone. In the report, it is recommended that the water and mud be removed from both spring locations, and that borrow material be placed in the excavation and be well compacted in layers of 6-to-8 inches to a point at last two feet above where spring water exits. Mr. Whitfield also recommends that at least three feet of natural soil be left in the lake and that all exposures of bedrock be padded with compacted clay to act as a sealant in preventing lake water from percolating into the underlying bedrock. Also, that the layer of in-place bedrock and soil should be left in the core trench to seal off possible hydrostatic spring water from moving upward into the dam and rupture the lake basin floor. In conclusion, Mr. Whitfield states that the recommendations contained in the report are subject to fallibility and may not be successful. And, it is emphasized that the best aid in preserving the lake is that at least three feet of natural soil be left undisturbed above the bedrock to prevent loss of water by seepage into the underlying sandstone. The extent to which these recommendations were followed during construction of the dam is unknown.

2.3 OPERATION

The lake level is uncontrolled and governed by the elevation of the crest of the principal, drop inlet type, spillway. An emergency spillway, with a crest elevation approximately 4.4 feet higher than the crest of the principal spillway and 6.0 feet lower than the top of the dam at its lowest point, is located at the left abutment. According to Dr. Winter, to his knowledge, the highest lake level experienced to date occurred in April of 1979 when the lake surface reached an elevation approximately 0.5 foot above the crest of the drop inlet spillway. However, according to Louis Sieve, who serves as caretaker for the property and resides nearby, the highest level he could recall occurred 5 or 6 years ago when the lake surface reached an elevation that produced a depth of flow at the emergency spillway of about 1.0 foot. Both Dr. Winter and Mr. Sieve reported that the dam has never been overtopped, and no indication was found that it had been.

2.4 EVALUATION

a. Availability. Detailed engineering data for assessing the design of the dam and spillways were unavailable.

b. Adequacy. Available data inadequate. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Winter Lake Dam was made by Horner & Shifrin engineering personnel, R. E. Sauthoff, Civil Engineer, H. B. Lockett, Hydrologist, and A. B. Becker, Jr., Civil and Soils Engineer, on 28 August 1980. An examination of the dam area was also made by an engineering geologist, Jerry D. Higgins, Ph.D., a consultant retained by Horner & Shifrin for the purpose of assessing the site geology. Also examined at the time of the inspection were the areas and features below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on pages A-1 through A-5 of Appendix A. The locations of the photographs taken during the inspection are indicated on Plate 3.

b. Site Geology. The dam area is located within the Salem Plateau Section of the Ozark Plateaus Physiographic Province near the border with the Dissected Till Plains Section of the Central Lowlands Province. The topography is moderately steep, with a maximum of approximately 270 feet of relief between the reservoir and the surrounding drainage divides. Bedrock exposures at the site and borings immediately north of the area indicate the underlying bedrock consists of Ordovician-age sedimentary strata of the Jefferson City-Cotter and the Roubidoux formations. The bedrock is dipping slightly northward. No faults were observed or have been reported in the vicinity of the site.

The Jefferson City-Cotter is a light brown, medium to finely crystalline dolomite. It is thin-to-medium-bedded, often argillaceous, and cherty. Solution enlargement of joints and bedding planes frequently occurs in the dolomite, and the contact between bedrock and the overlying surficial materials is usually an irregular surface. These solution features commonly make the dolomites very permeable. The Jefferson City-Cotter is exposed in the reservoir area at water level. The Roubidoux formation consists of sandstone, dolomitic sandstone, and cherty dolomite. The sandstone is composed of fine-to-medium-grained quartz sand varying in color from tan or

SECTION 3 - VISUAL INSPECTION

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The unconsolidated surficial materials consist primarily of thin, residual cherty clays, alluvium, and loess. The residual soils cover much of the reservoir site. They are composed of stony, blocky, silty clays. According to the Unified Soil Classification System, the soil ranges from GM to GC material. The valley floor is covered by very cherty clay (CL) alluvium. Both soils are moderately permeable and are often the source of reservoir leakage. Loessal soils (ML) cap the surrounding ridges; however, little is present at the reservoir site.

The dam appears to be much too high for the observed level of the reservoir. It is thought that seepage through the thin soils into the permeable bedrock has contributed to (if not caused) this condition. This is a common problem in regions where solution-weathered carbonates and sandstones are covered by thin residual soils.

The most significant geologic problem at the site is the possible severe reservoir leakage into bedrock. No other adverse geologic conditions were observed that would be considered to affect the stability or performance of the dam.

c. <u>Dam</u>. The visible portions of the upstream and downstream faces of the dam (see Photos 1 and 2), as well as the dam crest, were examined and found to be in sound condition, although a hole about 10 inches in diameter, believed to be an animal burrow (see Photo 10), was present in the upstream face of the dam adjacent to the drop inlet spillway structure. No cracking of the surface, sloughing of the embankment slopes, or undue settlement of the dam crest was noted. A good stand of grass, a fescue type, about 3 feet high, covered the unprotected areas of the dam. The upstream face of the dam was protected by riprap, quarry-run limestone up to about 2 feet in diameter, that extended from the wave berm at elevation 519.0± to about 1 foot below the observed level of the lake, or about elevation 511.5. No significant erosion of the dam proper or the abutment slopes was noticed, and no seepage was evident at the abutments or the downstream area adjacent to the dam. Sycamore and willow trees, up to about 2 inches in diameter, and dense undergrowth were found along the wave berm across the entire upstream face of the dam. Trees up to 4 inches in diameter were found in the embankment in the vicinity of the outlet pipe for the principal spillway, and numerous smaller trees were found elsewhere across the downstream face of the dam. Examination of a soil sample obtained from the downstream face of the embankment indicated the surficial material to be a reddish-brown, lean clay (CL) of medium plasticity.

The above ground portions of the 42-inch diameter steel drop inlet structure (see Photo 3), including the anti-vortex plate and bar type trash rack, were examined and, except for a light coating of rust on the unprotected steel surfaces and areas of the anti-vortex plate where the paint had failed, were found to be in satisfactory condition. The outlet end of the 30-inch diameter steel outlet pipe (see Photo 4) was also examined and, except for a light coating of rust on the unprotected surfaces (the exterior surface of the pipe was protected by about a 0.10-inch bituminous coating, although the coating was missing from about the last 2.5 feet of pipe), was in good condition. However, the pipe was unsupported for approximately 3 feet at the end of the outlet. A pool of water (see Photo 9), approximately 15 feet wide by 30 feet long and 2 feet deep, was found just downstream of the spillway outlet. It appeared that the pool was a result of scour of the outlet channel bottom by pipe discharges. It could not be determined if the water in the pool was in part due to underseepage. Some flow, on the order of 1-to-2 gpm, was noticed in the outlet channel downstream of the pool and, since there was no pipe discharge at the time, in all likelihood, the source of the flow in the channel was seepage from the lake. However, the possibility that the springs reported to be in the core trench at the right abutment and 200 feet east of the right abutment (about the location of the pool), may still exist and cannot be discounted as a source of water in the pool or flow in the channel.

The emergency spillway and spillway outlet channel were inspected and found to be in reasonably good condition although the upstream end of the crest section (see Photo 5) was somewhat congested by small trees and brush. The crest section of the spillway (see Photo 6) was in satisfactory condition and no signs of erosion were evident. The exit section of the spillway outlet (see Photo 7), judging by the mature appearance of the trees in the channel area, appeared to be unimproved. Several fallen trees on the order of 8 inches in diameter were also found within the channel (the channel is a natural drainage swale for the adjoining watershed) just downstream of the exit section. The oulet channel for the emergency spillway through the area downstream of the dam was not well defined (see Photo 8), but appeared to join the principal spillway outlet channel at a point about 150 feet south of the base of the dam.

d. Appurtenant Structures. No appurtenant structures were observed at this dam site.

e. Downstream Channel. Except at the railroad and highway crossings, the channel downstream of the dam is unimproved. The section is irregular and for the most part lined with trees. The stream joins the Bourbeuse River about 0.4 mile downstream of the dam.

f. Reservoir. Except for the upstream end of the valley for the southeast trending tributary to the lake, which is under cultivation, and the area in the immediate vicinity of the old house located on the east side of the lake, which is grass covered and well kept, the area surrounding the lake is covered with trees. No significant erosion of the lake banks was noticed. At the time of the inspection, the lake was approximately 7.5 feet below normal pool level and the water within the reservoir was clear. The amount of sediment within the lake could not be determined at the time of the inspection; however, due to the vegetation covering the surrounding area, it is not expected to be significant.

3.2 EVALUATION

The deficiencies observed during the inspection and noted herein are not considered significant to warrant immediate remedial action. However, it is recommended that, as soon as practical, the trees and brush be removed from the embankment and the dam, particularly the upstream face, be re-examined for signs of burrowing animals. It is also recommended that the embankment at the end of the spillway outlet pipe, as well as the eroded channel bottom just downstream of the pipe, be restored, and some form of protection provided to prevent future erosion by spillway discharges.

The stone riprap on the upstream face of the dam appears to be adequate to prevent erosion of the slope by wave action or by fluctuations of the lake level.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillways are uncontrolled. The lake surface level is governed by precipitation runoff, evaporation, seepage, and the capacities of the uncontrolled principal and emergency spillways.

4.2 MAINTENANCE OF DAM

According to Dr. John Winter, one of the Owners, the grass on the dam has never been cut; however, the trees have been cut one time since completion of construction, and, with this exception, the dam has received no further maintenance.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No outlet facilities requiring operation exist at this dam, and there is no reservoir regulation plan.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

The inspection did not reveal the existence of a dam failure warning system.

4.5 EVALUATION

Judging by the dense growth of brush and trees on the upstream face of the dam, as well as the erosion that was observed at the downstream end of the spillway outlet pipe, the inspection team is of the opinion that maintenance of the dam proper has been somewhat neglected.

Lack of or inadequate maintenance is considered detrimental to the safety of a dam. It is recommended that maintenance of the dam and spillways be undertaken on a regular basis and that records be kept of all major items of maintenance work performed. It is also recommended that a detailed inspection of the dam be instituted on a regular basis by an engineer experienced in the design and construction of dams and that records be kept of all inspections made and remedial measures taken.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data were not available.

b. Experience Data. The drainage area and lake surface area were developed from the 1969 Moselle, Missouri, Quadrangle Map. The proportions and dimensions of the spillways and dam were developed from surveys made during the inspection. Records of rainfall, stream flow or flood data for the watershed are not available.

Due to the fact that the watershed for this reservoir is comparatively small, the lake level was assumed to be at normal pool as a result of antecedent storms prior to occurrence of the PMF and the probabilistic storm.

According to the St. Louis District, Corps of Engineers, the estimated flood damage zone, should failure of the dam occur, extends one mile downstream of the dam.

c. Visual Observations.

1. The principal spillway, a 42-inch diameter steel drop inlet, is located near the center of the dam. The drop inlet riser section is about 12.5 feet deep. A bar type trash rack above the top of the inlet serves as a trash screen.

2. A 30-inch diameter steel pipe extends from the drop inlet to a point about 4 feet above the toe of the dam at the downstream channel. The outlet pipe extends about 3 feet beyond the ground surface at the outlet end, and an erosion pool, about 2 feet deep, has formed below the end of the pipe at the toe of the dam.

3. The emergency spillway, a shallow broad-crested trapezoidal section, is located in the hillside of the left, or east, abutment.

4. The emergency spillway outlet channel, a natural earth section, joins the original stream channel about 150 feet downstream of the toe of the dam. The channel section is irregular and may not contain spillway flow throughout.

5. A pond, on the order of three-quarters of an acre in surface area, lies adjacent to the upstream end of the east side of the lake. A small dam serves to confine water to the lake. According to survey data obtained during the inspection, the top of the dam at its lowest point is approximately 4.2 feet higher than the crest of the principal spillway of the Winter Lake Dam, about 0.2 foot lower than the emergency spillway, and roughly 6.2 feet lower than the top of the Winter Dam. Since the pond is relatively small, approximately three-quarters of an acre, and since, for lake levels higher than the top of the pond dam, the pond will be inundated by the main lake, the presence of the pond was ignored in the hydraulic/hydrologic investigations performed for the Winter Lake Dam and presented herein.

d. Overtopping Potential. The spillways (principal and emergency) are inadequate to pass the probable maximum flood, or 1/2 the probable maximum flood, without overtopping the dam. The spillways are adequate, however, to pass the lake outflow resulting from the 1 percent chance flood without overtopping the dam. The results of the dam overtopping analyses are as follows:

(Note: The data appearing in the following table have been extracted from the computer output data appearing in Appendix B. Decimal values have been rounded to the nearest one-tenth in order to prevent assumption of unwarranted accuracy.)

Ratio of PMF	Q-Peak Outflow (cfs)	Max. Lake W.S. Elev.	Max. Depth (Ft.) of Flow over Dam (Elev. 530.4)	Duration of Overtopping of Dam (Hrs.)
0.50	3,839	531.2	0.8	0.7
1.00	10,606	533.1	2.7	2.0
1% chance flood	375	526.1	0.0	0.0

Elevation 530.4 was found to be the lowest point in the dam crest. The flow safely passing the spillway just prior to overtopping amounts to approximately 2,773 cfs, which is the routed outflow corresponding to about 40 percent of the probable maximum flood inflow. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 2.7 feet and overtopping will extend across the entire length of the dam.

e. Evaluation. Experience with embankments constructed of similar material (a silty clay of medium plasticity) to that used to construct this dam has shown evidence that the material, under certain conditions, such as high velocity flow, can be quite erodible. Such a condition exists during the PMF when large lake outflow, accompanied by high flow velocities, occurs. For the PMF condition where the depth of flow over the dam crest, a maximum of 2.7 feet, and the duration of flow over the dam, 2.0 hours, are substantial, damage by erosion to the crest and downstream face of the dam is expected. The extent of these damages is not predictable within the scope of these investigations; however, there is a possibility that they could result in failure by erosion of the dam.

f. References. Procedures and data for determining the probable maximum flood, the 100-year frequency flood, and the discharge rating curve for flow passing the spillways and dam crest are presented on pages B-1 through B-3 of the Appendix. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood and the 100-year frequency flood are shown on pages B-4 through B-6. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-7 through B-10; tabulation of lake surface area, elevation and storage volume is shown on page B-11 and tabulations titled "Summary of Dam Safety Analysis" for the PMF and 1 percent chance (100-year frequency) flood are also shown on page B-11.

SECTION 6- STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1c.

b. Design and Construction Data. Detailed design or construction data relating to the structural stability of the dam were not available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were also not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Operating Records. No appurtenant structures or facilities requiring operation exist at this dam. According to Dr. John Winter, one of the Owners, no records are kept of the lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Changes. According to Dr. Winter, no post construction changes have been made or have occurred which would affect the structural stability of the dam.

e. Seismic Stability. The dam is located within a Zone II seismic probability area. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicated that the spillways (principal plus emergency) are capable of passing lake outflow of about 2,773 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicates that for storm runoff of probable maximum flood magnitude, the lake outflow would be about 10,606 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 375 cfs.

Seepage and stability analyses of the dam were not available for review, and therefore, no judgment could be made with respect to the structural stability of the dam.

Several items were noticed during the inspection that could adversely affect the safety of the dam. These items include trees and brush on the dam slopes, an animal burrow in the upstream face of the embankment, and the area of erosion at the downstream toe of the dam in the vicinity of the spillway outlet pipe.

b. Adequacy of Information. Due to lack of detailed design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessments of the hydrology of the watershed and capacities of the spillways were based on a hydraulic/hydrologic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. The remedial measures recommended in paragraph 7.2 for the items concerning the safety of the dam noted in paragraph 7.1a should be accomplished in the near future. The item recommended in paragraph 7.2a regarding the provision of additional spillway capacity should be pursued on a high priority basis. It is also recommended that, as soon as practical, the trees and brush be removed from the embankment and that the entire embankment be re-examined, as stated, after it is cleared.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. The dam is located within a Zone II seismic probability area. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended:

1. Based upon criteria set forth in the recommended guidelines, spillway size and/or height of dam should be increased in order to pass lake outflow resulting from a storm of probable maximum flood magnitude; in any event, the spillways should be protected to prevent erosion.

2. Obtain the necessary soil data and perform dam seepage and stability analyses in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of earthen dams. The presence of the pool at the toe of the dam should be taken into consideration when stability analyses of the dam are performed or provisions should be made to extend the outlet pipe beyond the toe of the dam to a location that will not erode the material adjacent to the embankment which could impair the stability of the dam.

b. Operations and Maintenance (O & M) Procedures. The following O & M Procedures are recommended:

1. Remove the trees and brush from the dam. Once the dam is cleared of trees and brush, it should be re-examined for additional signs of burrowing animals. All holes should be filled with impervious material (clay) and the existing turf cover should be restored if destroyed or missing. Maintain the turf cover at a height that will not hinder inspection of the embankment or provide cover for burrowing animals. Holes from tree roots and voids created by burrowing animals can provide pathways for lake seepage that could lead to a piping condition (progressive internal erosion) and potential failure of the dam.

2. Provide maintenance of all areas of the dam and spillways on a regularly scheduled basis in order to insure features of being in satisfactory operational condition.

3. A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections made and remedial measures taken.

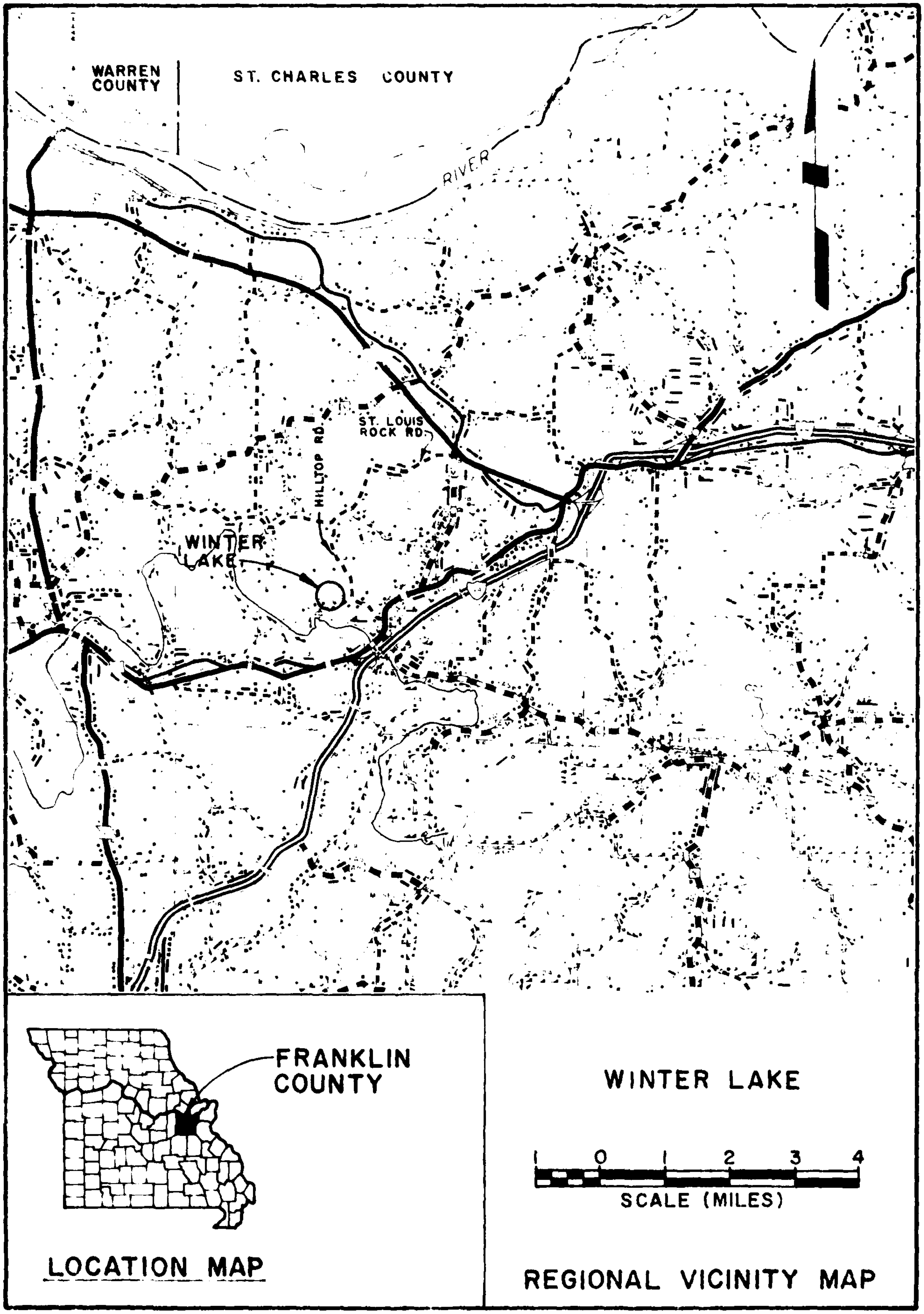
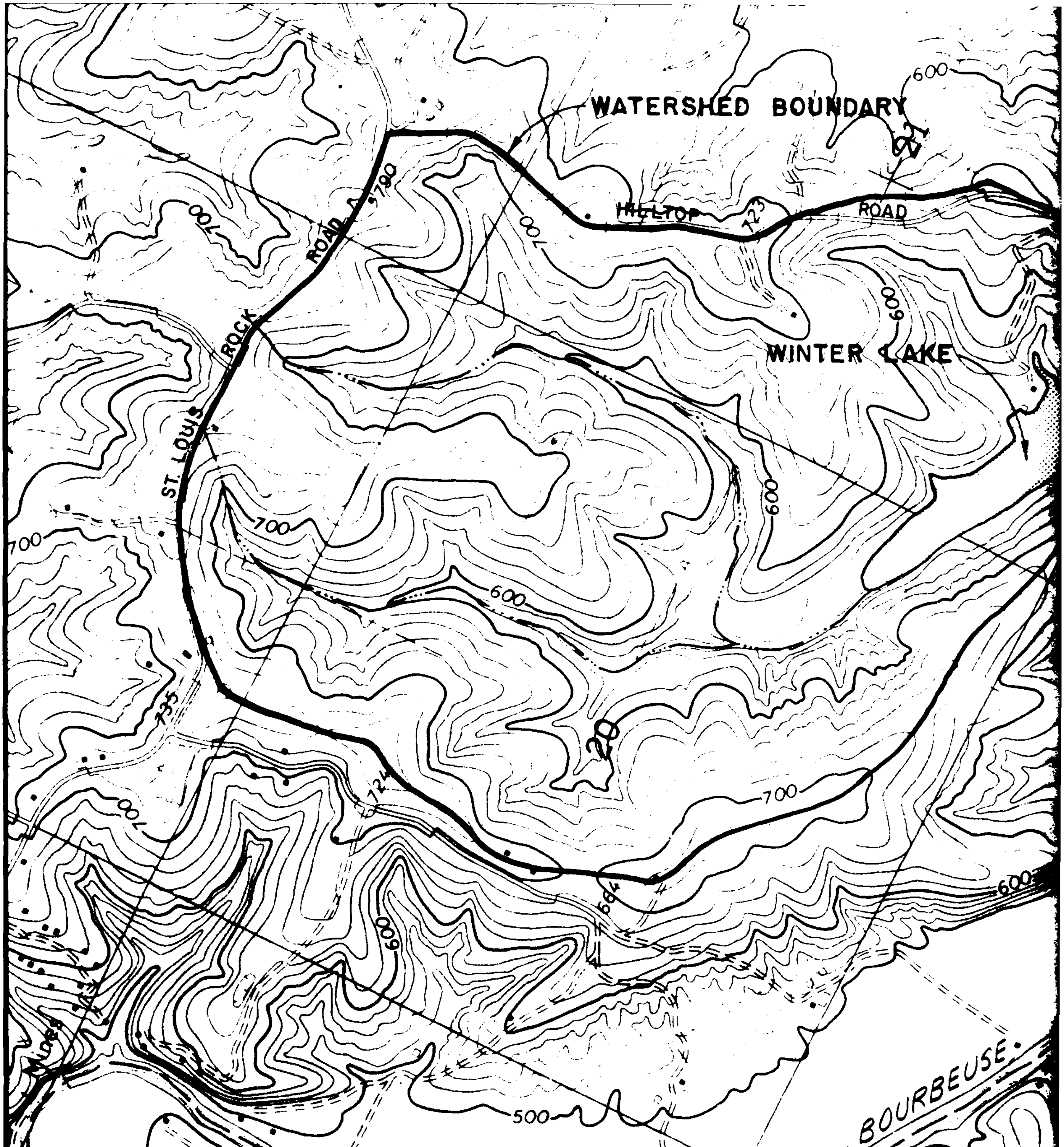

WARREN COUNTY
ST. CHARLES COUNTY
RIVER
ST. LOUIS ROCK RD.
HILLTOP RD.
WINTER LAKE
FRANKLIN COUNTY
LOCATION MAP
WINTER LAKE
1 0 1 2 3 4
SCALE (MILES)
REGIONAL VICINITY MAP

PLATE I


WATERSHED BOUNDARY
HILLTOP ROAD
WINTER LAKE
ST. LOUIS ROCK ROAD
BOURBEUSE
A=APPROXIMATE EXTENT OF DOWNSTREAM FLOOD DAMAGE ZONE

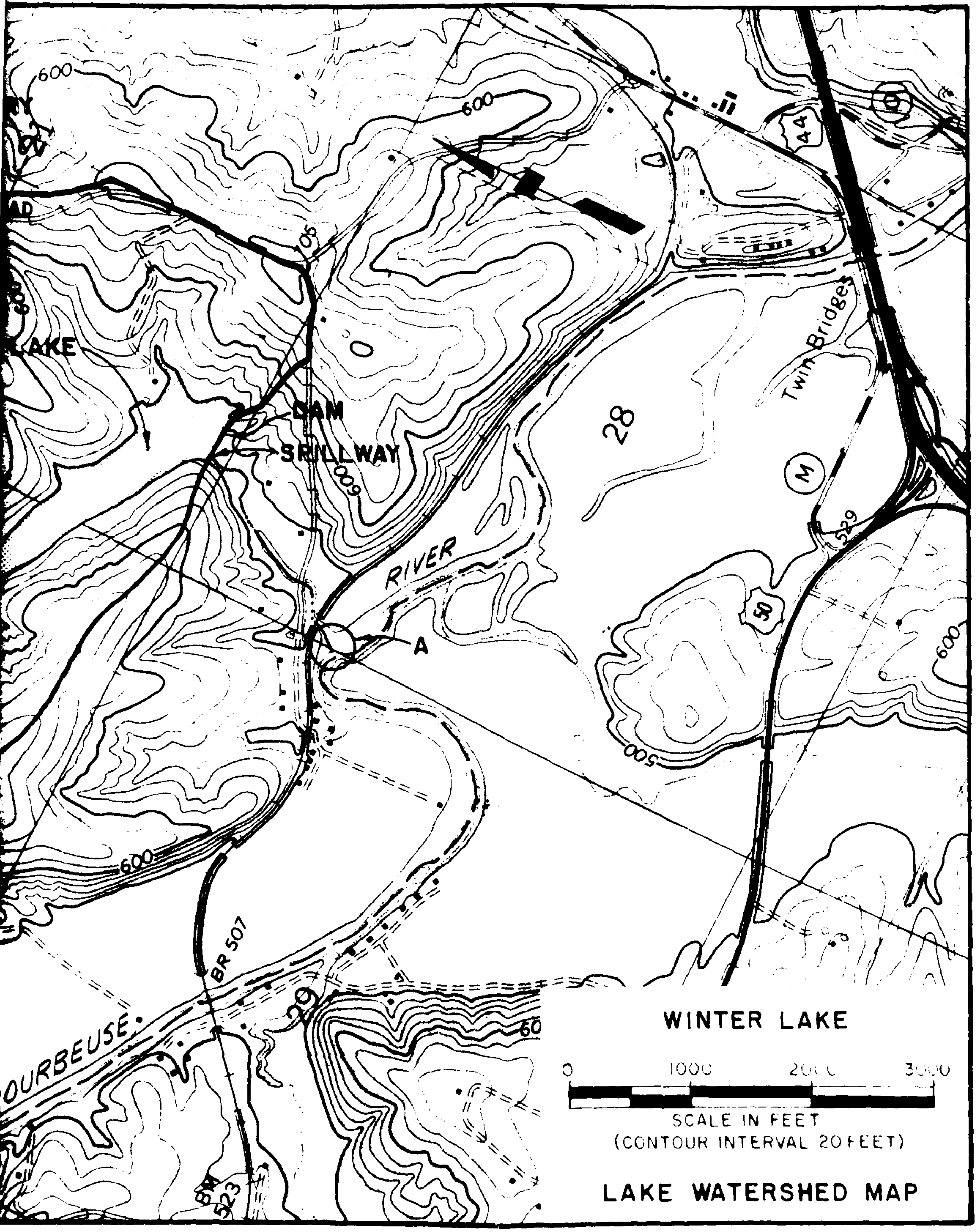
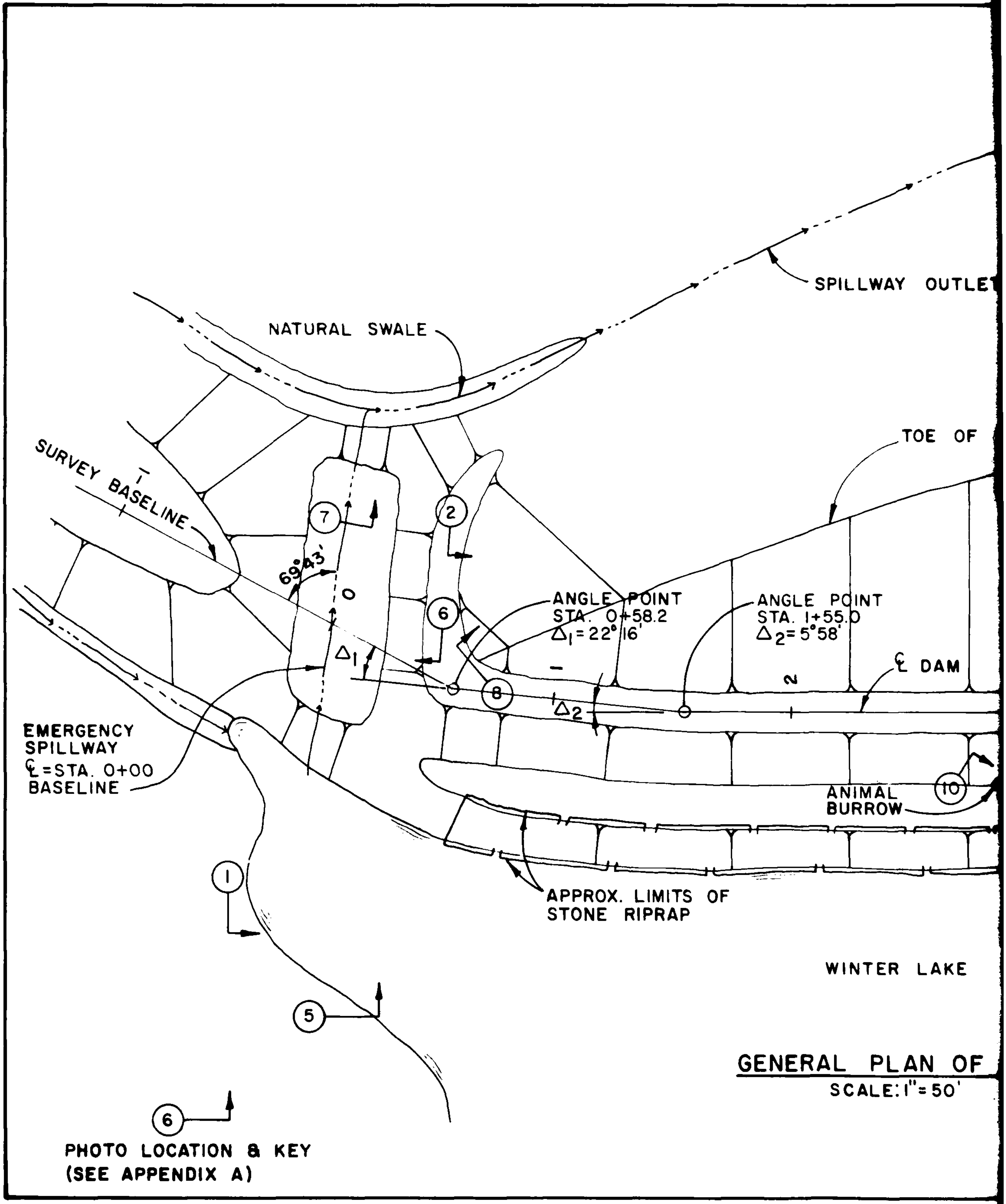

600
600
LAKE
DAM
SPILLWAY
600
RIVER
A
28
Twin Bridges
M
529
50
44
600
500
600
BR 507
29
BOURBEUSE
BM 523
WINTER LAKE
0
1000
2000
3000
SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)
LAKE WATERSHED MAP

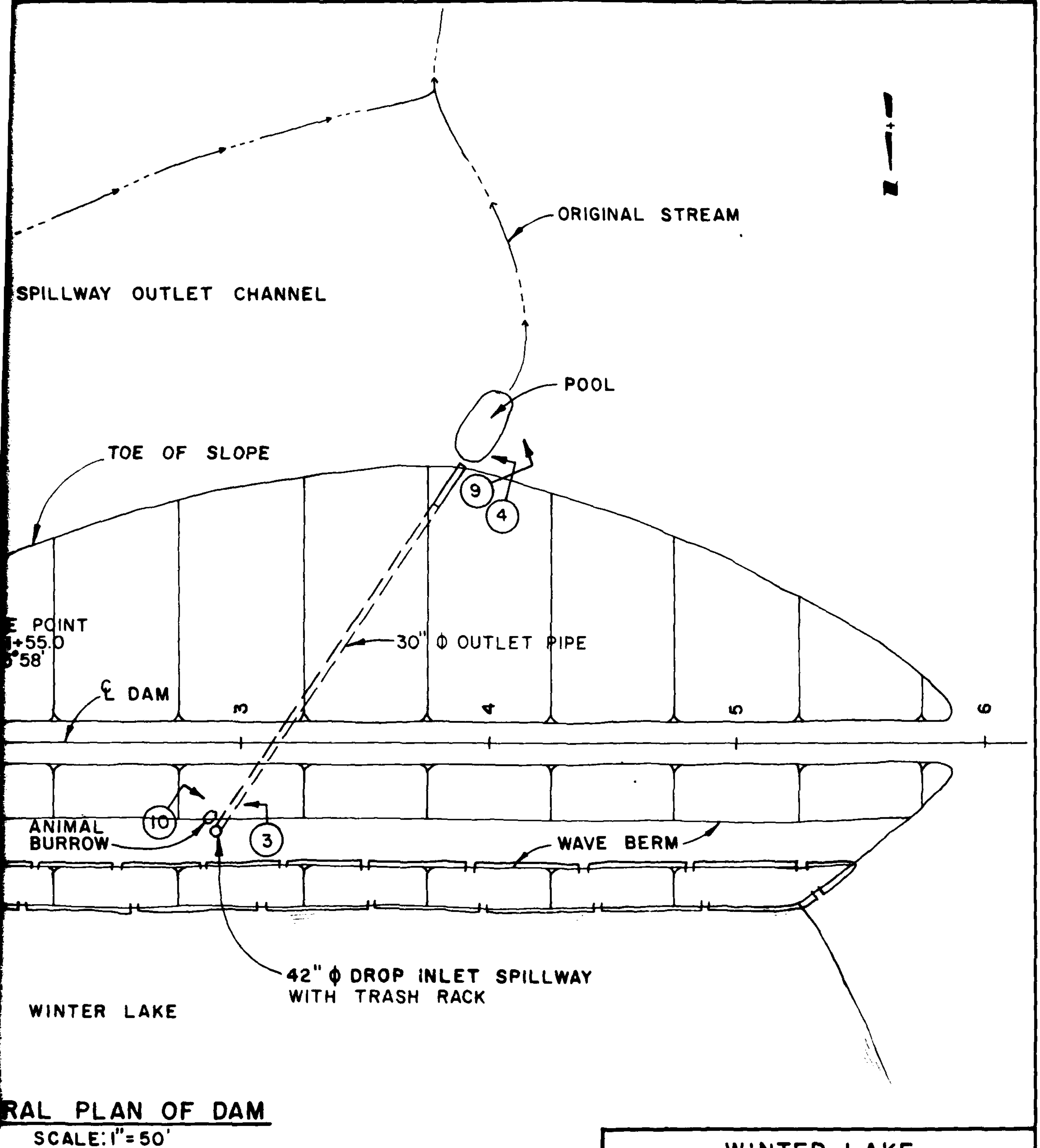
PLATE 2

12



GENERAL PLAN OF

SCALE: 1" = 50'



WINTER LAKE
DAM PLAN

Horner & Shifrin, Inc. Sept. 1980

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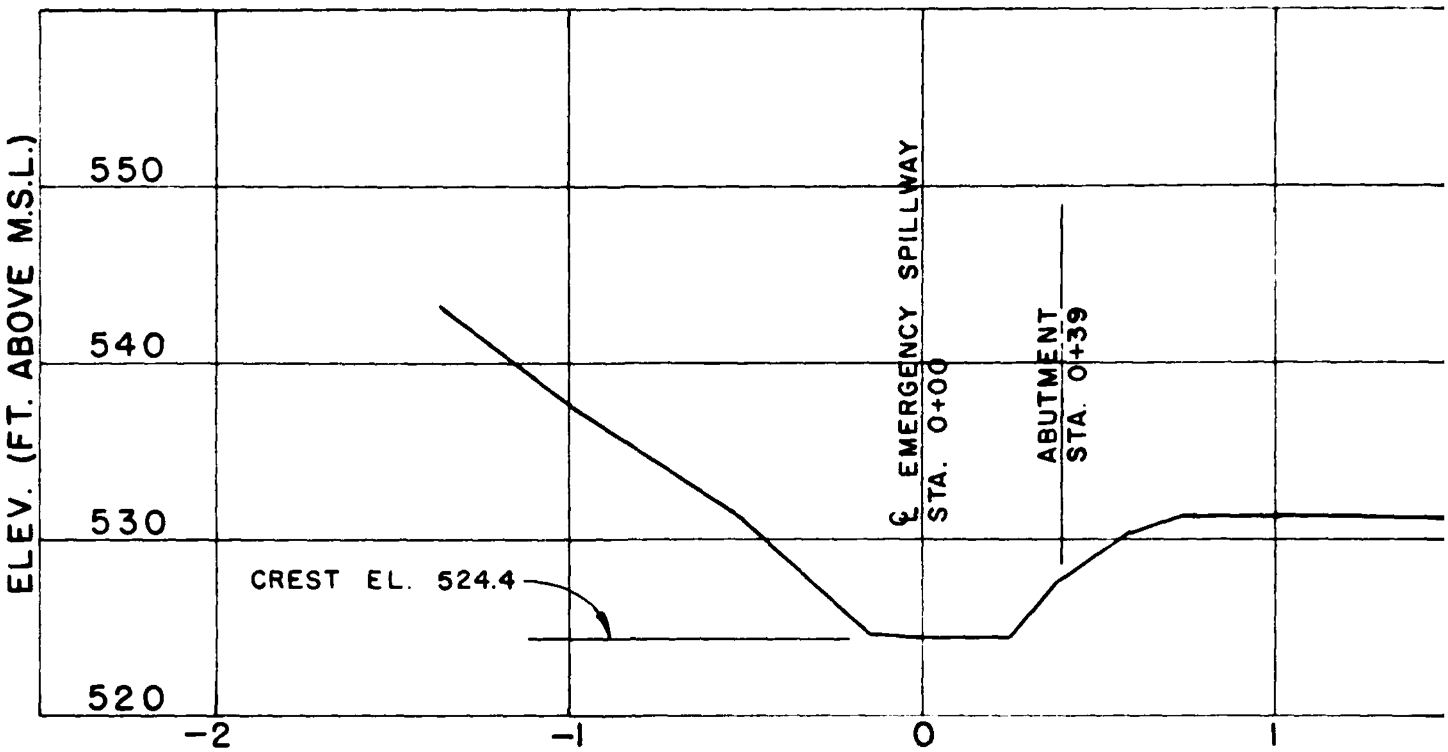
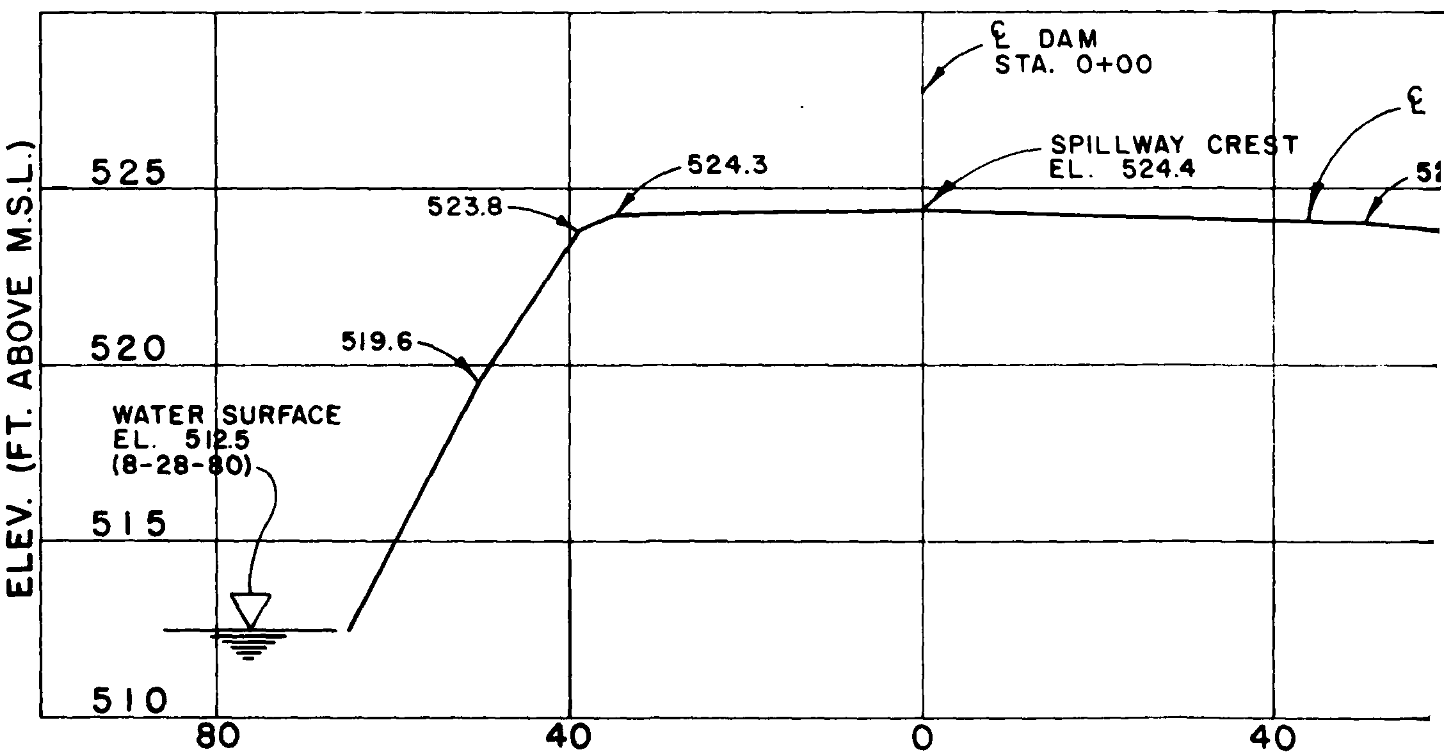
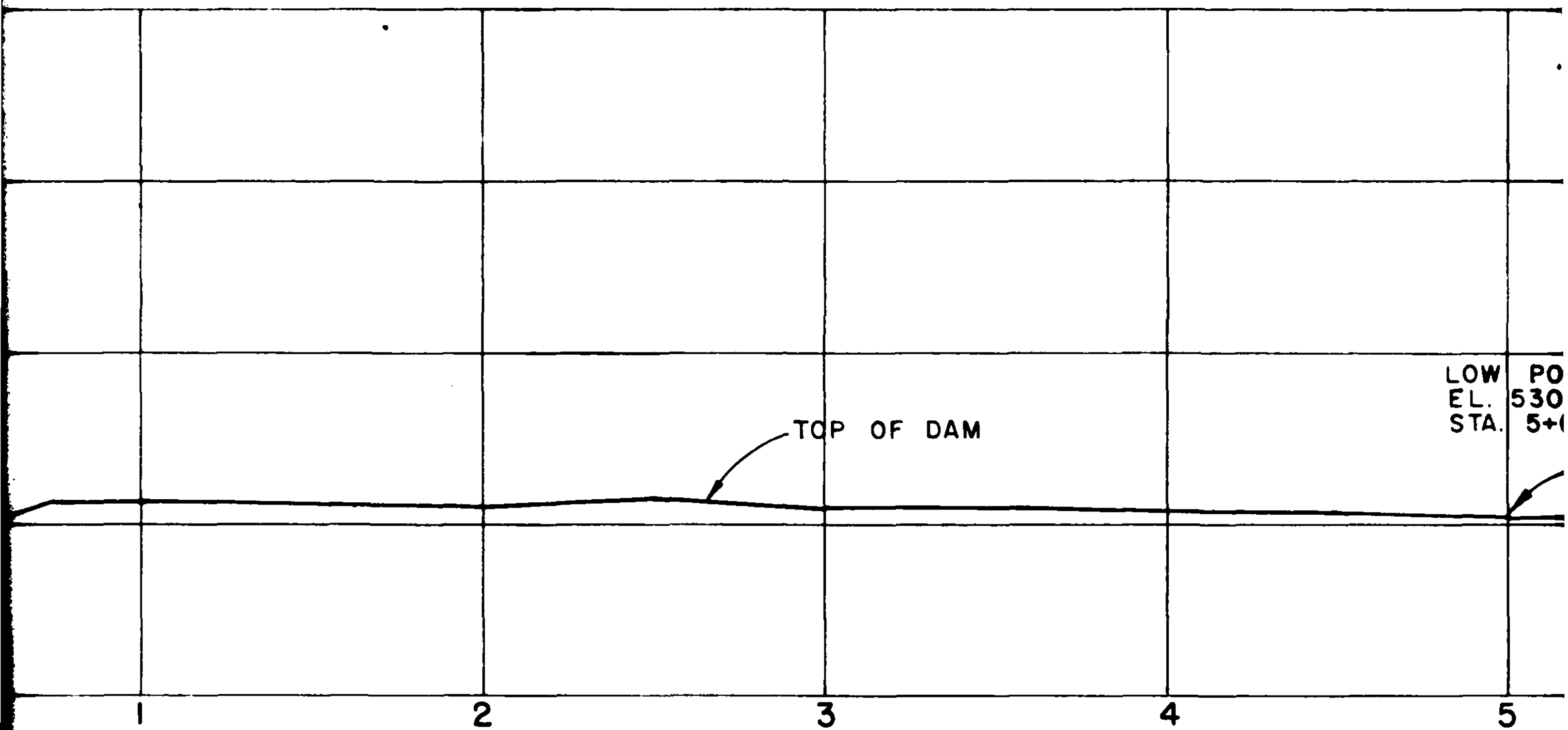
PLATE 3





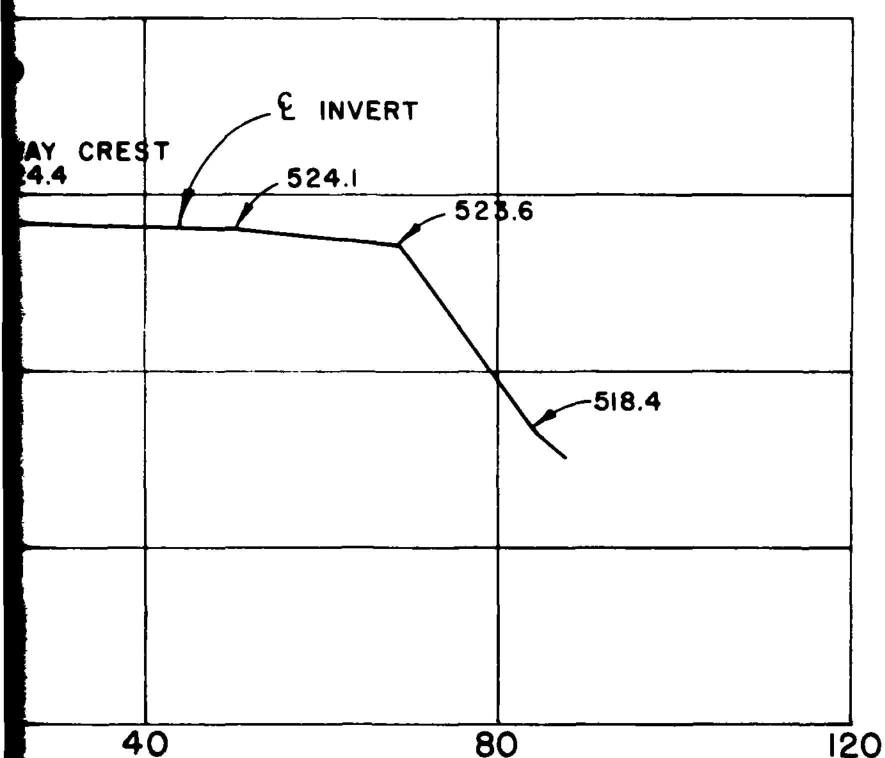
EMERGENCY SPILLWAY PROFILE

SCALE 1"=5'V., 1"=20'H.



PROFILE DAM CREST

SCALE: 1"=10'V., 1"=50'H.



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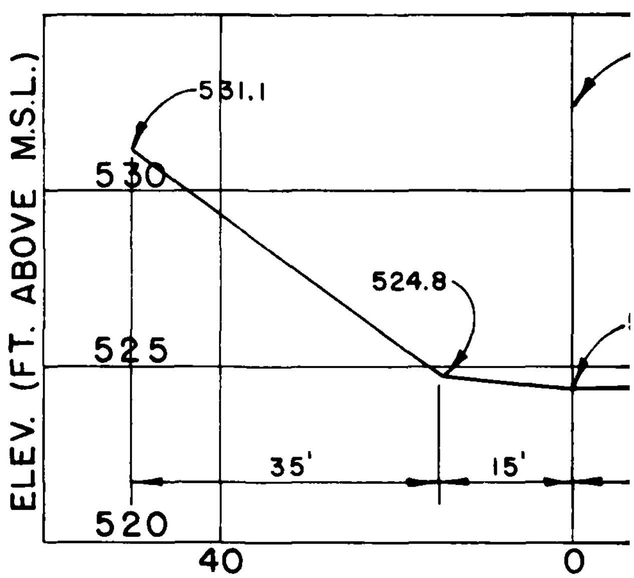
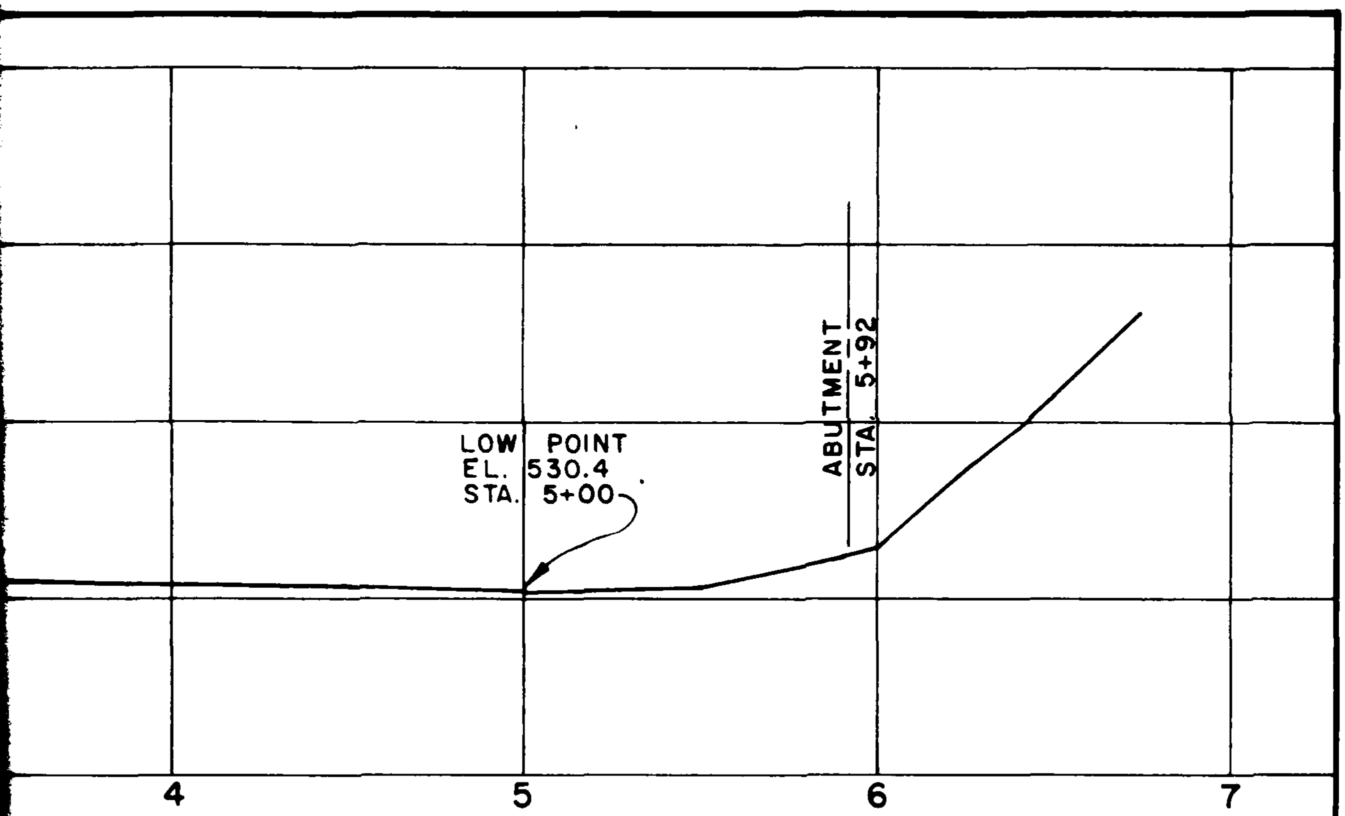
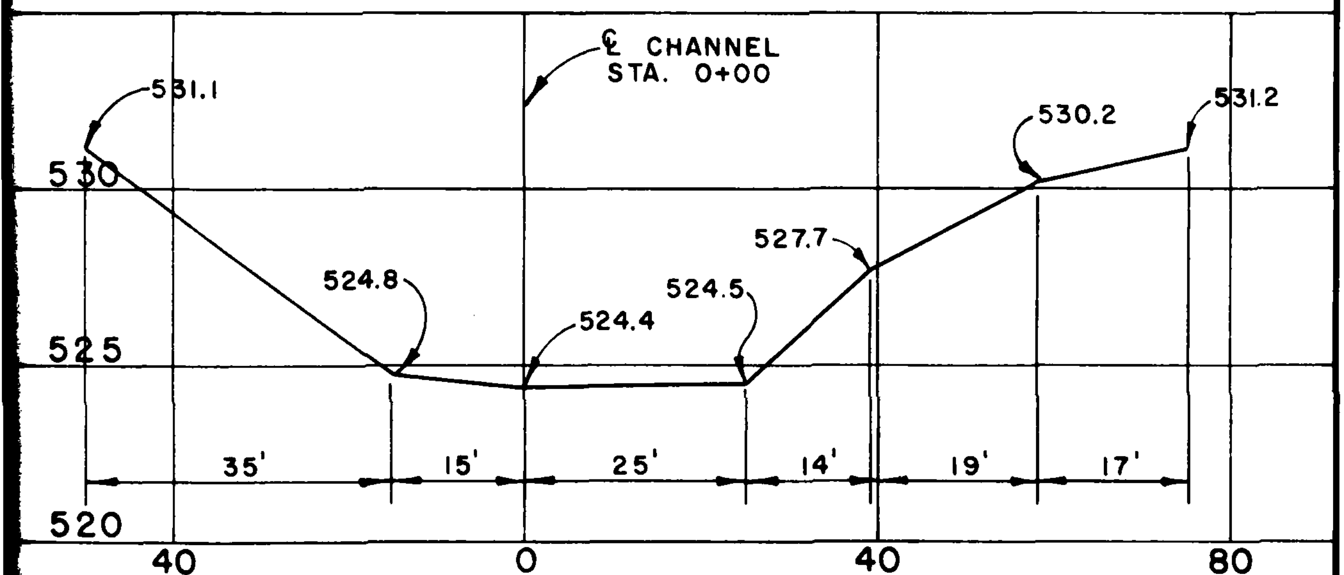


EMERGENCY SPILLWA

SCALE



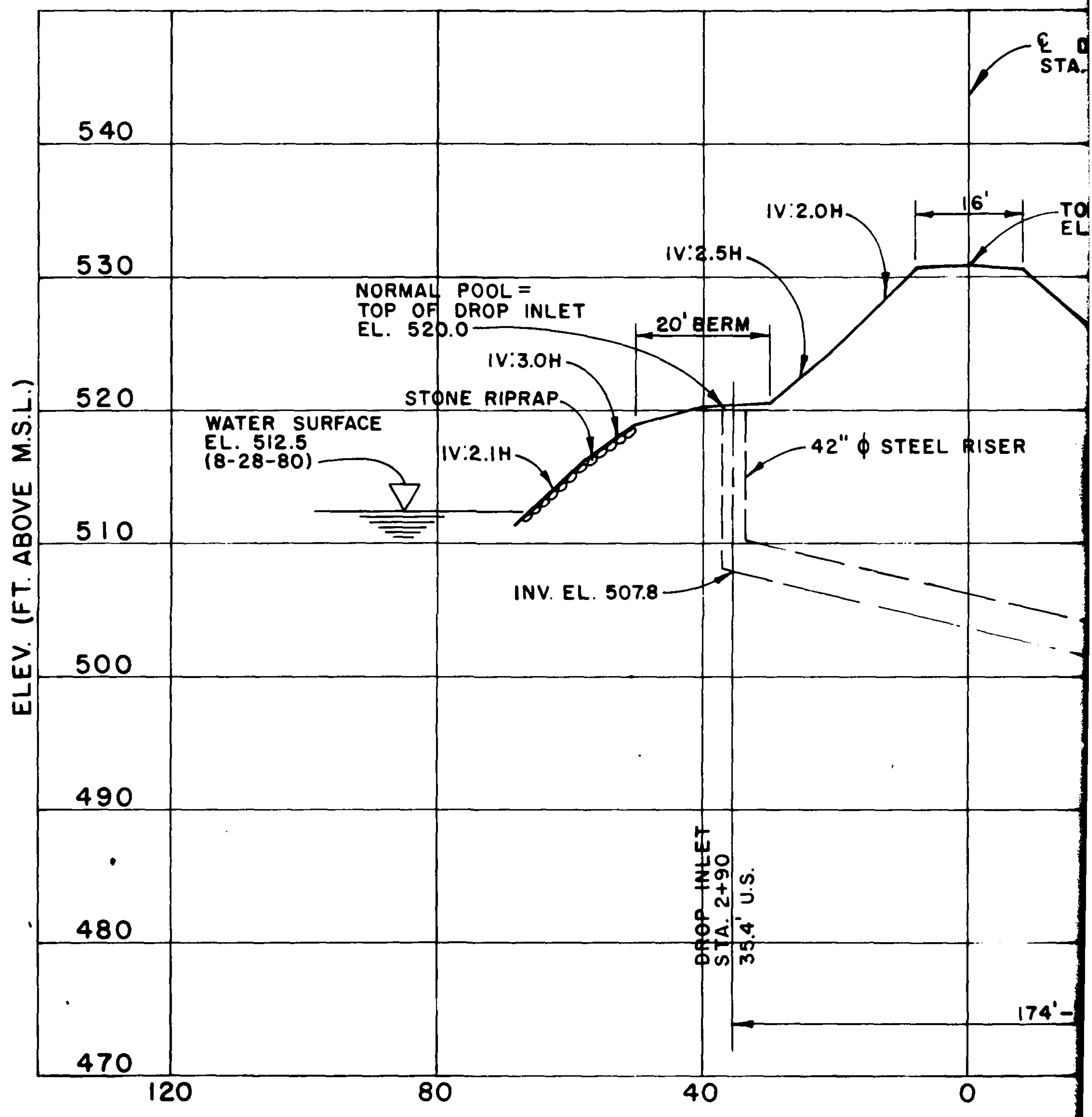


EMERGENCY SPILLWAY CROSS-SECTION — ℄ DAM

SCALE: 1"=5' V., 1"=20' H.

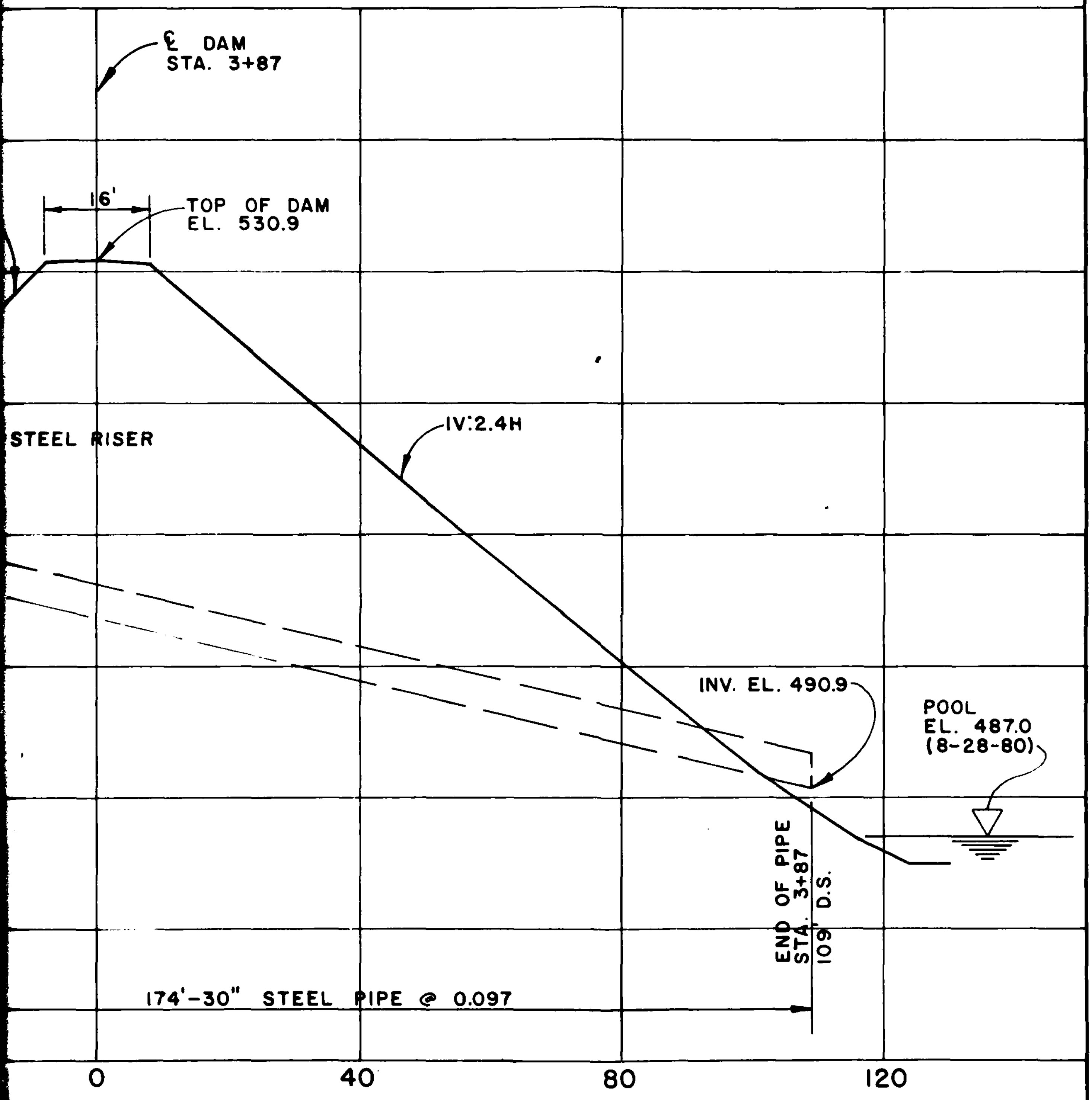
WINTER LAKE
PROFILE DAM CREST
EMERGENCY SPILLWAY

Horner & Shifrin, Inc. Sept. 1980



DAM CROSS-SECTION & PRINCIPAL

SCALE: 1"=10' V., 1"=20



& PRINCIPAL SPILLWAY PROFILE

LE: 1"=10' V., 1"=20' H.

WINTER LAKE
DAM CROSS-SECTION &
SPILLWAY PROFILE

Horner & Shifrin, Inc. Sept. 1980

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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SCS-375 Rev. 4-63
Sheet 1 of 2
For In Service Use Only

PRELIMINARY GEOLOGIC INVESTIGATION OF DAM SITES

Watershed ______ Subwatershed ______ Site no. ____ County Franklin State Mo

Location S¼ S¼ Sec 21 T43N R1E Site group I Structure class b Fund class 2

Nearest post office Union, Mo Landowner/operator John Winter

Drainage area: 1.01 sq. mi. 650 acres. Purpose(s) of structure Recreation

Embankment: Length 900 ft. Height 35 ft. Cubic yards 50,000 Est. storage capacity 300 ac. ft.

This investigation made by: Inspection of surface ✓ Hand auger ____ Test pits ____ Other(specify) ____

Investigated by: [illegible], geologist (Signature and Title) 11-4-68 (Date)

GENERAL GEOLOGY

Physiographic description Ozark Highlands Geologic formation(s) Roubidoux - Jefferson City

Attitude: Strike — Dip —

Direction of valley axis (downstream) SE Steepness of abutments: Left 20 percent, Right 35 percent

Material of abutment and valley walls Rock outcrops on the lower right abutment, The left abutment and valley walls are covered with cherty residual clay (CL)

Surficial deposits alluvium of the valley floor.

Faults, folds, joints, caverns and slide areas (describe briefly): None noted at the site. The general locality is an area of known faulting

Depths to and kind of rock in foundation Sandstone occurs in the channel and outcrops on the right abutment, The Jefferson City outcrops upstream Depth to groundwater — Date measured —

Leakage problems Some seepage in the sandstone but not a serious hazard.

EMERGENCY SPILLWAY

Best location: Left abutment ✓ Right abutment ____ Other ____

Estimated excavation: Volume NK yds.; Percent rock NK ; Suitable for fill? Yes Type S.S. Dolo. or CL (GC, CL, etc.)

Erodibility of control section NK (high, medium, low or very low) Erodibility of exit channel medium (high, medium, low or very low)

STREAM OR OUTLET CHANNEL

Description: width ____ ft.; Depth ____ ft.; Bed material ____ °D ____ Size of bed material ____ in.

Channel: Scouring ____ Aggrading ____ Stable ____ ; Banks: Eroding ____ Stable ____

Insert 50 or 75

(continued on reverse side)

Chart 2-1

BORROW AREAS

No. ______ Location ____________ Direction from dam ______ Distance __________ Probable depth __________ Area ________

Cubic yards available ____________ Description of material ______________________________

____

Description of materials underlying borrow area ______________________________

______________________________ Depth to water _______ Are salts or dispersed soils present? ______

. . . .

No. ______ Location ____________ Direction from dam ______ Distance __________ Probable depth __________ Area ________

Cubic yards available ____________ Description of material ______________________________

____

Description of materials underlying borrow area ______________________________

______________________________ Depth to water _______ Are salts or dispersed soils present? ______

SUMMARY OF FINDINGS, INTERPRETATIONS, AND CONCLUSIONS

[illegible]face investigation indicates a suitable site however subsurface investigation is recommended. This investigation should determine the character of the rock [illegible] the right abutment and beneath the alluvium, the depth core, the extent of the cutoff and any seepage hazard. The strength of the foundation materials does not appear to be a problem. Excavations of the emergency spillway overburden can be used for borrow. Other borrow is available from the lower slopes, and the alluvium within reasonable haul distance of the centerline.

RECOMMENDATIONS FOR FURTHER INVESTIGATIONS

(Including type of equipment required and estimated cost)

Core & pressure Test the rock of the right abutment to emergency spillway elevation and at least 1 hole in the channel and one other hole on the flood-plain. Determine the depth of the overburden on the flood plain, the left abutment and the emergency spillway. Estimated cost $1200.

Attach logs, sketches, maps and other pertinent data

GPO 802-777

Chart 2-2

UNITED STATES DEPARTMENT OF [illegible]
SOIL CONSERVATION SERVICE
P.O.Box 621, Fulton, Missouri 65251

Dr. John Winter
12205 Blackheath Ct.
Creve Coeur, Missouri

August 7, 1969

Dear Dr. Winter:

The following additional items will be required to meet our specifications on your lake construction. These items were not included in your original contract and would require a negotiated agreement concerning payment between you and Mr. Williams.

A. Five - 6 ft. 6 in. x 6 ft. 6 in. anti-seep collars
   Note: Two 5 ft. x 5 ft. 6 in. collars were shown on original design

B. 54 in. x 54 in. x 3/8 in. smooth iron base plate for riser.

C. Wood pier support for outlet end of pipe (see attached drawing).

D. Rip Rap Quantities
   Rock Fill Required = 106 c.y. (see attached dwg.)
   Rock Fill included in contract = 100 c.y.
   Additional Quantity = 6 c.y.

Attached also is a copy of our specifications for construction of your lake.

Sincerely yours,

Warren W. Pflantz

Warren W. Pflantz
Area Engineer

cc: DC Shotwell

Attachments

Chart 2-3

ENGINEERING GEOLOGY REPORT FOR THE WINTER DAM, FRANKLIN COUNTY, MISSOURI

LOCATION: SW¼ SW¼ sec. 21, T. 43 N., R. 1 E.

A request was received by the Missouri Geological Survey from Mr. Greg Williams, contractor, to inspect the core trench of the Winter Dam, in which springs had been encountered during excavation.

An inspection of the core trench showed that the springs occurred at the base of the west abutment and in the central portion of the core trench approximately 200 feet east of the west abutment.

The spring in the west abutment is in a layer of soft Roubidoux formation sandstone, 8 to 12 inches in thickness. The spring occurs where the abutment slope and valley floor intersect.

The spring is in the middle of the core trench beneath approximately four feet of Roubidoux sandstone. This spring was uncovered during ripping operations by the contractor in placing the core trench into firm bedrock. The springs egress is in a layer of soft sandstone 6 to 8 inches thick.

RECOMMENDATIONS:

It is recommended that at both spring locations the water be pumped out and mud removed. Borrow material should be placed in the excavation and be well compacted in layers of 6 to 8 inches to a point at least two feet above the point where spring water exits.

It is recommended that at least three feet of natural soil be left in the lake and all exposures of bedrock be padded with compacted clay to act as a sealant in preventing lake water from percolating into the underlying bedrock. Also, the layer of in-place bedrock and soil should be left in the core trench to seal off possible hydrostatic spring water from moving upward into the dam and rupture the lake basin floor.

SUMMARY:

If it is decided to abandon this site and move to another, it is quite possible that the same trouble will occur. By placing compacted borrow clay over the springs, costs will be kept to a minimum and construction work already completed will not have to be abandoned.

It should be realized however, that these recommendations are subject to fallibility and may not be successful.

It is emphasized again that the best aid in preserving the lake is that at least three feet of natural soil be left undisturbed above the bedrock to prevent loss of lake water by seepage into the underlying sandstone.

John W. Whitfield

John W. Whitfield
Engineering Geologist
Missouri Geological Survey
August 5, 1969

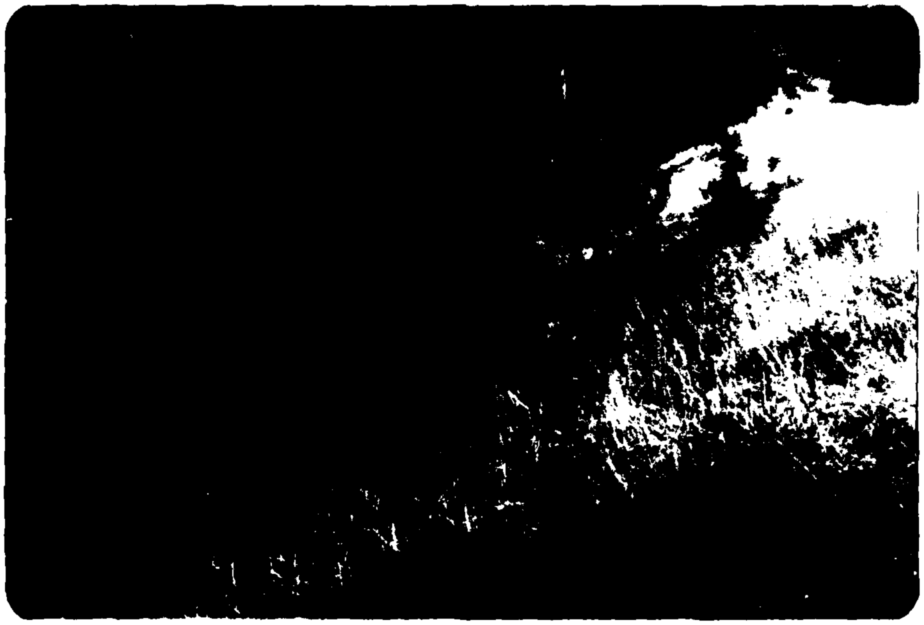
Chart 2-4

copy to: Greg Williams

APPENDIX A

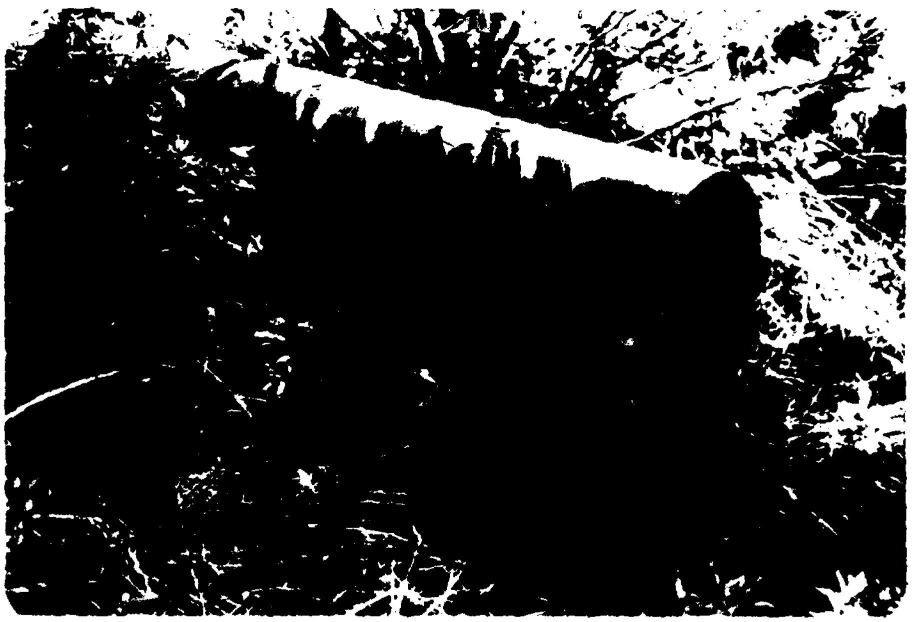
INSPECTION PHOTOGRAPHS

NO. 1: UPSTREAM FACE OF DAM



NO. 2: DOWNSTREAM FACE OF DAM

NO. 3: 42" DIAMETER DROP INLET SPILLWAY



NO. 4: OUTLET END OF 30" SPILLWAY OUTLET PIPE

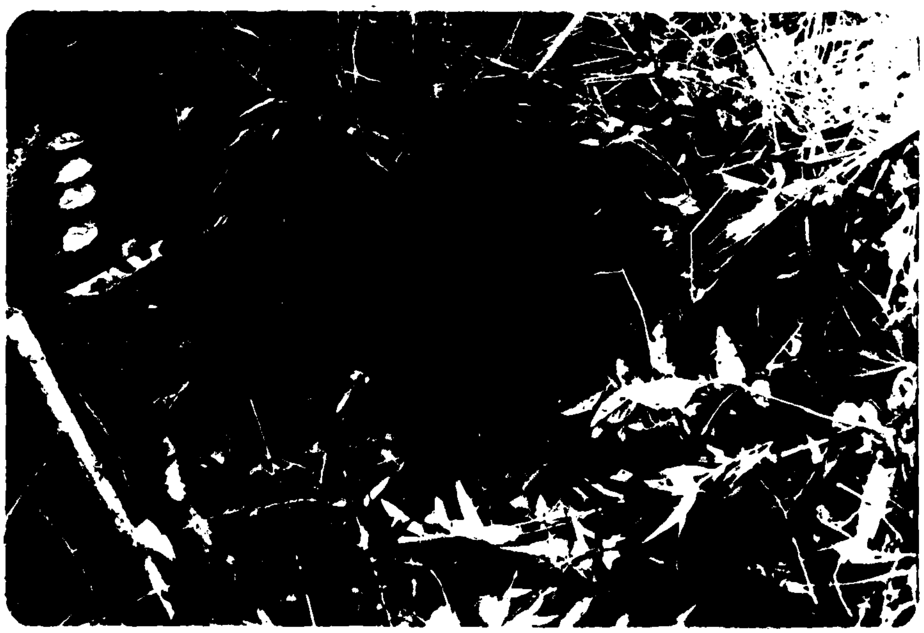
NO. 5: EMERGENCY SPILLWAY (RIGHT CENTER OF PICTURE)

NO. 6: CREST OF EMERGENCY SPILLWAY

NO. 7: EMERGENCY SPILLWAY - LOOKING DOWNSTREAM FROM CREST

NO. 8: OVERVIEW OF AREA DOWNSTREAM OF DAM

NO. 9: POOL DOWNSTREAM OF SPILLWAY OUTLET PIPE



NO. 10: ANIMAL BURROW IN UPSTREAM FACE OF DAM

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 25.4 inches) from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent chance (100-year freguency) flood was provided by the St. Louis District, Corps of Engineers.

b. Drainage area = 1.172 square miles = 750 acres.

c. SCS parameters:

$$\text{Time of Concentration } (T_C) = \left(\frac{11.9L^3}{H}\right)^{0.385} = 0.443 \text{ hours}$$

Where: T_C = Travel time of water from hydraulically most distant point to point of interest, hours

L = Length of longest watercourse = 1.345 miles

H = Elevation difference = 240 feet

The time of concentration (T_C) was obtained using Method C as described in Figure 30, "Design of Small Dams", by the United States Department of the Interior, Bureau of Reclamation, and was verified using average channel velocity estimates and watercourse lengths.

Lag time = 0.266 hours (0.60 T_C)

Hydrologic Soil Group = C (Predominantly, Gatewood and Bucklick Series, per unpublished SCS Soil Survey Data)

Soil type CN = 75 (AMC II, 100-yr flood)
= 88 (AMC III, PMF condition)

2. Spillway releases for the drop inlet spillway were computed utilizing equations and nomographs presented in "Design of Small Dams" by the U. S. Department of the Interior (USDI) for drop inlet type spillways. The rise of the nappe above the elevation of the crest lip was considered negligible. The following equation was used for crest control:

$$Q = C_o \, (2\pi R_s) \, H_o^{3/2}$$

where "C_o is a coefficient obtained from Figure 283 of the above reference, expressed in terms of H_o/R_s, "R_s" is the radius of the spillway crest, 1.75 feet, and "H_o" is the depth of flow over the crest.

When the ratio H_o/R_s reached a value of 1.00, inflow was determined by assuming flow was over a sharp edge submerged orifice. The following equation was used: $Q = Ca\,(2gh)^{0.5}$, where "C" is a coefficient assumed to be 0.6, "a" is the area of the orifice, 9.62 sf, "h" is the height of flow above the orifice, and "g" is acceleration due to gravity. Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, page 4-3.

Flow through the 30-inch diameter outlet pipe was determined using Bernoulli's equation for pressure flow in pipes. Losses, including throat, entrance, turn, pipe and exit losses totaled 3.40 velocity heads. Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, pages 8-5 and 8-6.

Discharge quantities, determined by the methods described herein, were plotted versus corresponding lake water surface elevations to determine the discharge rating curve for the drop inlet spillway.

3. The emergency spillway section consists of a broad-crested, trapezoidal section for which conventional weir formulas do not apply.

Spillway release rates were determined as follows:

a. Spillway crest section properties (areas, "a", and top width, "t") were computed for various depths, "d".

b. It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth Q_c was computed as $Qc = \left(\frac{a^3 g}{t}\right)^{0.5}$ for the various depths, "d". Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.* Reference, "Handbook of Hydraulics", Fifth Edition, by King and Brater, page 8-7.

c. Static lake levels corresponding to the various values passing the spillway were computed as critical depths plus critical velocity heads (d_c+H_{vc}), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

d. The discharges for the principal and emergency spillways for equal elevations were summated for entry on the Y4 and Y5 cards.

4. The profile of the dam crest is irregular and flow over the dam cannot be determined by application of conventional weir formulas. Crest length and elevation data for the dam crest proper were entered into the HEC-1 Program on the $L and $V cards. The program assumes that flow over the dam crest section occurs at critical depth and computes internally the flow over the dam crest and adds this flow to the flow passing the spillway as entered on the Y4 and Y5 cards.

* $v_c = \frac{Qc}{a}$; $Hvc = \frac{v_c^2}{2g}$

A1	ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF									
A2	HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF WINTER LAKE DAM									
A3	RATIOS OF PMF ROUTED THROUGH RESERVOIR									
B	288	0	5	0	0	0	0	0	0	0
B1	5									
J	1	4	1							
J1	0.40	0.41	0.50	1.00						
K	0	INFLOW					1			
K1	INFLOW HYDROGRAPH									
M	1	2	1.172			1.0			1	
P	0	25.4	102	120	130					
T							-1	-88		
W2		0.266								
X	-1.0	-.10	2.0							
K	1	DAM					1			
K1	RESERVOIR ROUTING BY MODIFIED PULS									
Y				1	1					
Y1	1						237.67	-1		
Y4	520.0	520.35	521.05	521.75	522.80	524.40	524.94	525.52	526.09	526.65
Y4	527.33	528.00	528.54	529.57	530.83	532.09	533.21	534.58	535.94	
Y5	0	9	37	52	66	83	124	227	368	545
Y5	812	1132	1423	2089	3127	4422	5850	7965	10357	
$A	0	23.0	33.4	47.1	64.1					
$E	489	520	530	540	550					
$$	520.0									
$D	530.4									
$L	0	83	168	331	464	492	517	525	565	600
$V	530.4	530.6	530.9	531.1	531.3	531.4	532.4	533.0	539.7	546.2
K	99									

```
`1A1       ANALYSIS OF DAM OVERTOPPING USING 100-YR FLOOD
A2        HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF WINTER LAKE DAM
A3        100-YR FLOOD ROUTED THROUGH RESERVOIR
D      240       0       6                                               4
B1       5
J        1       1       1
J1    1.00
K        0  INFLOW                                  1
K1        INFLOW HYDROGRAPH
M        0       2   1.172                   1.0                         1
O      240   7.218
O1    .008    .008    .008    .008    .008    .008    .008    .008    .008    .008
O1    .008    .008    .008    .008    .008    .008    .008    .008    .008    .008
O1    .008    .008    .008    .008    .008    .008    .008    .008    .008    .008
O1    .008    .008    .008    .008    .008    .008    .008    .008    .008    .008
O1    .008    .008    .008    .008    .008    .008    .008    .008    .008    .008
O1    .008    .008    .008    .008    .008    .008    .008    .008    .008    .008
O1    .017    .017    .017    .017    .017    .017    .017    .017    .017    .017
O1    .017    .017    .017    .017    .017    .017    .017    .017    .017    .017
O1    .017    .017    .017    .017    .017    .017    .017    .017    .017    .017
O1    .026    .026    .026    .026    .026    .026    .026    .026    .026    .026
O1    .026    .026    .026    .026    .026    .037    .037    .037    .037    .037
O1    .073    .073    .073    .073    .073    .158    .159    .159    .301    .593
O1    .933    .380    .301    .159    .159    .073    .073    .073    .073    .073
O1    .037    .037    .037    .037    .037    .026    .026    .026    .026    .026
O1    .026    .026    .026    .026    .026    .026    .026    .026    .026    .026
O1    .017    .017    .017    .017    .017    .017    .017    .017    .017    .017
```

100-YR. FLOOD (Cont'd)

```
01  .017     .017     .017     .017     .017     .017     .017     .017     .017     .017
01  .017     .017     .017     .017     .017     .017     .017     .017     .017     .017
01  .008     .008     .008     .008     .008     .008     .008     .008     .008     .008
01  .008     .008     .008     .008     .008     .008     .008     .008     .008     .008
01  .008     .008     .008     .008     .008     .008     .008     .008     .008     .008
01  .008     .008     .008     .008     .008     .008     .008     .008     .008     .008
01  .008     .008     .008     .008     .008     .008     .008     .008     .008     .008
01  .008     .008     .008     .008     .008     .008     .008     .008     .008     .008
T                                                        -1      -75
W2           0.266
X   -1.0     -.10      2.0
K      1      DAM                                         1
K1        RESERVOIR ROUTING BY MODIFIED PULS
Y                                    1        1
Y1     1                                               237.67     -1
Y4 520.0   520.35   521.05   521.75   522.80   524.40   524.94   525.52   [illegible]  [illegible]
Y4527.33   528.00   528.54   529.57   530.83   532.09   533.21   534.58   535.74
Y5     0        ?       37       52       66       83      124      227    [illegible]   545
Y5   812     1102     1423     2089     3127     4422     5850   [illegible] [illegible]
$A     0   [illegible] 33.4    47.1     64.1
$E   480      520      530      540      550
$1 520.0
$D 530.4
$L     0       83      168      331      464      492      517      525      565      600
$V 530.4    530.6    530.9    531.1    531.3    531.4    532.4    533.0    537.7    546.2
K     99
A
```

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF WINTER LAKE DAM
RATIOS OF PMF ROUTED THROUGH RESERVOIR

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= .40 .41 .50 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INFLOW	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	1.17	0.00	1.17	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.40	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-88.00	0.00	0.00

CURVE NO = -88.00 WETNESS = -1.00 EFFECT CN = 88.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .27

RECESSION DATA
STRTQ= -1.00 QRCSN= -.10 RTIOR= 2.00

UNIT HYDROGRAPH 18 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .27 VOL= 1.00

301.	1010.	1725.	1824.	1502.	994.	611.	403.	257.	167.
105.	68.	44.	28.	19.	13.	7.	2.		

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	1.	1.01	12.05	145	.22	.21	.01	594.
1.01	.10	2	.01	0.00	.01	1.	1.01	12.10	146	.22	.21	.01	743.
1.01	.15	3	.01	0.00	.01	1.	1.01	12.15	147	.22	.21	.01	996.
1.01	.20	4	.01	0.00	.01	1.	1.01	12.20	148	.22	.21	.01	1265.
1.01	.25	5	.01	0.00	.01	1.	1.01	12.25	149	.22	.21	.01	1487.
1.01	.30	6	.01	0.00	.01	1.	1.01	12.30	150	.22	.21	.01	1634.
1.01	.35	7	.01	0.00	.01	1.	1.01	12.35	151	.22	.21	.01	1727.
1.01	.40	8	.01	0.00	.01	1.	1.01	12.40	152	.22	.21	.01	1789.
1.01	.45	9	.01	0.00	.01	1.	1.01	12.45	153	.22	.21	.01	1830.
1.01	.50	10	.01	0.00	.01	1.	1.01	12.50	154	.22	.21	.01	1858.
1.01	.55	11	.01	0.00	.01	1.	1.01	12.55	155	.22	.21	.01	1876.
1.01	1.00	12	.01	0.00	.01	1.	1.01	13.00	156	.22	.21	.00	1889.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.26	.25	.01	1911.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.25	.01	1960.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.26	.25	.00	2033.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.26	.25	.00	2120.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.26	.25	.00	2187.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.26	.25	.00	2231.
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.26	.26	.00	2259.
1.01	1.40	20	.01	.00	.01	0.	1.01	13.40	164	.26	.26	.00	2278.
1.01	1.45	21	.01	.00	.01	0.	1.01	13.45	165	.26	.26	.00	2291.
1.01	1.50	22	.01	.00	.01	1.	1.01	13.50	166	.26	.26	.00	2300.
1.01	1.55	23	.01	.00	.01	2.	1.01	13.55	167	.26	.26	.00	2306.
1.01	2.00	24	.01	.00	.01	3.	1.01	14.00	168	.26	.26	.00	2311.
1.01	2.05	25	.01	.00	.01	5.	1.01	14.05	169	.32	.32	.00	2333.
1.01	2.10	26	.01	.00	.01	7.	1.01	14.10	170	.32	.32	.00	2401.
1.01	2.15	27	.01	.00	.01	9.	1.01	14.15	171	.32	.32	.00	2513.
1.01	2.20	28	.01	.00	.01	11.	1.01	14.20	172	.32	.32	.00	2632.
1.01	2.25	29	.01	.00	.01	13.	1.01	14.25	173	.32	.32	.00	2730.
1.01	2.30	30	.01	.00	.01	15.	1.01	14.30	174	.32	.32	.00	2795.
1.01	2.35	31	.01	.00	.01	18.	1.01	14.35	175	.32	.32	.00	2835.
1.01	2.40	32	.01	.00	.01	20.	1.01	14.40	176	.32	.32	.00	2862.
1.01	2.45	33	.01	.00	.01	22.	1.01	14.45	177	.32	.32	.00	2880.
1.01	2.50	34	.01	.00	.01	24.	1.01	14.50	178	.32	.32	.00	2892.
1.01	2.55	35	.01	.00	.01	26.	1.01	14.55	179	.32	.32	.00	2900.
1.01	3.00	36	.01	.00	.01	27.	1.01	15.00	180	.32	.32	.00	2906.
1.01	3.05	37	.01	.00	.01	29.	1.01	15.05	181	.20	.20	.00	2871.
1.01	3.10	38	.01	.00	.01	31.	1.01	15.10	182	.39	.39	.00	2806.
1.01	3.15	39	.01	.00	.01	33.	1.01	15.15	183	.39	.39	.00	2788.
1.01	3.20	40	.01	.00	.01	34.	1.01	15.20	184	.59	.59	.00	2956.
1.01	3.25	41	.01	.00	.01	36.	1.01	15.25	185	.69	.69	.00	3352.
1.01	3.30	42	.01	.00	.01	38.	1.01	15.30	186	1.67	1.67	.01	4255.
1.01	3.35	43	.01	.00	.01	39.	1.01	15.35	187	2.76	2.75	.01	6212.
1.01	3.40	44	.01	.01	.01	41.	1.01	15.40	188	1.08	1.08	.00	9034.
1.01	3.45	45	.01	.01	.01	42.	1.01	15.45	189	.69	.69	.00	11270.
1.01	3.50	46	.01	.01	.01	44.	1.01	15.50	190	.59	.59	.00	11658.
1.01	3.55	47	.01	.01	.01	45.	1.01	15.55	191	.39	.39	.00	10529.
1.01	4.00	48	.01	.01	.01	46.	1.01	16.00	192	.39	.39	.00	8707.
1.01	4.05	49	.01	.01	.01	48.	1.01	16.05	193	.30	.30	.00	7055.
1.01	4.10	50	.01	.01	.01	49.	1.01	16.10	194	.30	.30	.00	5782.
1.01	4.15	51	.01	.01	.01	50.	1.01	16.15	195	.30	.30	.00	4790.
1.01	4.20	52	.01	.01	.01	51.	1.01	16.20	196	.30	.30	.00	4086.

END-OF-PERIOD FLOW (Cont'd)

1.01	4.25	53	.01	.01	.01	53.	1.01	16.25	197	.30	.30	.00	3603.
1.01	4.30	54	.01	.01	.01	54.	1.01	16.30	198	.30	.30	.00	3293.
1.01	4.35	55	.01	.01	.01	55.	1.01	16.35	199	.30	.30	.00	3096.
1.01	4.40	56	.01	.01	.01	56.	1.01	16.40	200	.30	.30	.00	2966.
1.01	4.45	57	.01	.01	.01	57.	1.01	16.45	201	.30	.30	.00	2886.
1.01	4.50	58	.01	.01	.01	58.	1.01	16.50	202	.30	.30	.00	2832.
1.01	4.55	59	.01	.01	.01	59.	1.01	16.55	203	.30	.30	.00	2792.
1.01	5.00	60	.01	.01	.01	60.	1.01	17.00	204	.30	.30	.00	2764.
1.01	5.05	61	.01	.01	.01	61.	1.01	17.05	205	.24	.24	.00	2729.
1.01	5.10	62	.01	.01	.01	62.	1.01	17.10	206	.24	.24	.00	2657.
1.01	5.15	63	.01	.01	.01	63.	1.01	17.15	207	.24	.24	.00	2542.
1.01	5.20	64	.01	.01	.01	64.	1.01	17.20	208	.24	.24	.00	2423.
1.01	5.25	65	.01	.01	.01	65.	1.01	17.25	209	.24	.24	.00	2325.
1.01	5.30	66	.01	.01	.01	66.	1.01	17.30	210	.24	.24	.00	2261.
1.01	5.35	67	.01	.01	.01	67.	1.01	17.35	211	.24	.24	.00	2222.
1.01	5.40	68	.01	.01	.01	68.	1.01	17.40	212	.24	.24	.00	2196.
1.01	5.45	69	.01	.01	.01	69.	1.01	17.45	213	.24	.24	.00	2179.
1.01	5.50	70	.01	.01	.01	70.	1.01	17.50	214	.24	.24	.00	2169.
1.01	5.55	71	.01	.01	.01	70.	1.01	17.55	215	.24	.24	.00	2162.
1.01	6.00	72	.01	.01	.01	71.	1.01	18.00	216	.24	.24	.00	2158.
1.01	6.05	73	.06	.04	.03	81.	1.01	18.05	217	.02	.02	.00	2090.
1.01	6.10	74	.06	.04	.02	112.	1.01	18.10	218	.02	.02	.00	1870.
1.01	6.15	75	.06	.04	.02	165.	1.01	18.15	219	.02	.02	.00	1496.
1.01	6.20	76	.06	.04	.02	223.	1.01	18.20	220	.02	.02	.00	1153.
1.01	6.25	77	.06	.04	.02	275.	1.01	18.25	221	.02	.02	.00	1076.
1.01	6.30	78	.06	.04	.02	312.	1.01	18.30	222	.02	.02	.00	1004.
1.01	6.35	79	.06	.04	.02	339.	1.01	18.35	223	.02	.02	.00	937.
1.01	6.40	80	.06	.05	.02	360.	1.01	18.40	224	.02	.02	.00	874.
1.01	6.45	81	.06	.05	.02	377.	1.01	18.45	225	.02	.02	.00	815.
1.01	6.50	82	.06	.05	.02	391.	1.01	18.50	226	.02	.02	.00	761.
1.01	6.55	83	.06	.05	.02	402.	1.01	18.55	227	.02	.02	.00	710.
1.01	7.00	84	.06	.05	.01	412.	1.01	19.00	228	.02	.02	.00	662.
1.01	7.05	85	.06	.05	.01	421.	1.01	19.05	229	.02	.02	.00	618.
1.01	7.10	86	.06	.05	.01	429.	1.01	19.10	230	.02	.02	.00	577.
1.01	7.15	87	.06	.05	.01	436.	1.01	19.15	231	.02	.02	.00	538.
1.01	7.20	88	.06	.05	.01	443.	1.01	19.20	232	.02	.02	.00	502.
1.01	7.25	89	.06	.05	.01	449.	1.01	19.25	233	.02	.02	.00	468.
1.01	7.30	90	.06	.05	.01	454.	1.01	19.30	234	.02	.02	.00	437.
1.01	7.35	91	.06	.05	.01	459.	1.01	19.35	235	.02	.02	.00	408.
1.01	7.40	92	.06	.05	.01	464.	1.01	19.40	236	.02	.02	.00	380.
1.01	7.45	93	.06	.05	.01	469.	1.01	19.45	237	.02	.02	.00	355.
1.01	7.50	94	.06	.05	.01	473.	1.01	19.50	238	.02	.02	.00	331.
1.01	7.55	95	.06	.05	.01	477.	1.01	19.55	239	.02	.02	.00	309.
1.01	8.00	96	.06	.05	.01	480.	1.01	20.00	240	.02	.02	.00	288.
1.01	8.05	97	.06	.05	.01	484.	1.01	20.05	241	.02	.02	.00	269.
1.01	8.10	98	.06	.05	.01	487.	1.01	20.10	242	.02	.02	.00	251.
1.01	8.15	99	.06	.06	.01	490.	1.01	20.15	243	.02	.02	.00	234.
1.01	8.20	100	.06	.06	.01	493.	1.01	20.20	244	.02	.02	.00	218.
1.01	8.25	101	.06	.06	.01	496.	1.01	20.25	245	.02	.02	.00	204.
1.01	8.30	102	.06	.06	.01	499.	1.01	20.30	246	.02	.02	.00	192.
1.01	8.35	103	.06	.06	.01	502.	1.01	20.35	247	.02	.02	.00	192.
1.01	8.40	104	.06	.06	.01	504.	1.01	20.40	248	.02	.02	.00	192.
1.01	8.45	105	.06	.06	.01	506.	1.01	20.45	249	.02	.02	.00	192.
1.01	8.50	106	.06	.06	.01	509.	1.01	20.50	250	.02	.02	.00	192.
1.01	8.55	107	.06	.06	.01	511.	1.01	20.55	251	.02	.02	.00	192.

END-OF-PERIOD FLOW (Cont'd)

1.01	9.00	108	.06	.06	.01	513.	1.01	21.00	252	.02	.02	.00	192.
1.01	9.05	109	.06	.06	.01	515.	1.01	21.05	253	.02	.02	.00	192.
1.01	9.10	110	.06	.06	.01	516.	1.01	21.10	254	.02	.02	.00	192.
1.01	9.15	111	.06	.06	.01	518.	1.01	21.15	255	.02	.02	.00	192.
1.01	9.20	112	.06	.06	.01	520.	1.01	21.20	256	.02	.02	.00	192.
1.01	9.25	113	.06	.06	.01	521.	1.01	21.25	257	.02	.02	.00	192.
1.01	9.30	114	.06	.06	.01	523.	1.01	21.30	258	.02	.02	.00	192.
1.01	9.35	115	.06	.06	.01	524.	1.01	21.35	259	.02	.02	.00	192.
1.01	9.40	116	.06	.06	.00	526.	1.01	21.40	260	.02	.02	.00	192.
1.01	9.45	117	.06	.06	.00	527.	1.01	21.45	261	.02	.02	.00	192.
1.01	9.50	118	.06	.06	.00	527.	1.01	21.50	262	.02	.02	.00	192.
1.01	9.55	119	.06	.06	.00	530.	1.01	21.55	263	.02	.02	.00	192.
1.01	10.00	120	.06	.06	.00	531.	1.01	22.00	264	.02	.02	.00	192.
1.01	10.05	121	.06	.06	.00	532.	1.01	22.05	265	.02	.02	.00	192.
1.01	10.10	122	.06	.06	.00	533.	1.01	22.10	266	.02	.02	.00	192.
1.01	10.15	123	.06	.06	.00	534.	1.01	22.15	267	.02	.02	.00	192.
1.01	10.20	124	.06	.06	.00	535.	1.01	22.20	268	.02	.02	.00	192.
1.01	10.25	125	.06	.06	.00	536.	1.01	22.25	269	.02	.02	.00	192.
1.01	10.30	126	.06	.06	.00	537.	1.01	22.30	270	.02	.02	.00	192.
1.01	10.35	127	.06	.06	.00	538.	1.01	22.35	271	.02	.02	.00	192.
1.01	10.40	128	.06	.06	.00	539.	1.01	22.40	272	.02	.02	.00	192.
1.01	10.45	129	.06	.06	.00	540.	1.01	22.45	273	.02	.02	.00	192.
1.01	10.50	130	.06	.06	.00	541.	1.01	22.50	274	.02	.02	.00	192.
1.01	10.55	131	.06	.06	.00	542.	1.01	22.55	275	.02	.02	.00	192.
1.01	11.00	132	.06	.06	.00	542.	1.01	23.00	276	.02	.02	.00	192.
1.01	11.05	133	.06	.06	.00	543.	1.01	23.05	277	.02	.02	.00	192.
1.01	11.10	134	.06	.06	.00	544.	1.01	23.10	278	.02	.02	.00	192.
1.01	11.15	135	.06	.06	.00	545.	1.01	23.15	279	.02	.02	.00	192.
1.01	11.20	136	.06	.06	.00	545.	1.01	23.20	280	.02	.02	.00	192.
1.01	11.25	137	.06	.06	.00	546.	1.01	23.25	281	.02	.02	.00	192.
1.01	11.30	138	.06	.06	.00	546.	1.01	23.30	282	.02	.02	.00	192.
1.01	11.35	139	.06	.06	.00	547.	1.01	23.35	283	.02	.02	.00	192.
1.01	11.40	140	.06	.06	.00	548.	1.01	23.40	284	.02	.02	.00	192.
1.01	11.45	141	.06	.06	.00	548.	1.01	23.45	285	.02	.02	.00	192.
1.01	11.50	142	.06	.06	.00	549.	1.01	23.50	286	.02	.02	.00	192.
1.01	11.55	143	.06	.06	.00	549.	1.01	23.55	287	.02	.02	.00	192.
1.01	12.00	144	.06	.06	.00	550.	1.02	0.00	288	.02	.02	.00	192.
									SUM	33.02	31.44	1.58	291361.
										(839.)(	799.)(	40.)(	8250.42)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	11658.	3195.	1011.	1011.	291260.
CMS	330.	90.	29.	29.	8248.
INCHES		25.36	32.11	32.11	32.11
MM		644.10	815.54	815.54	815.54
AC-FT		1584.	2006.	2006.	2006.
THOUS CU M		1954.	2474.	2474.	2474.

SURFACE AREA=	0.	23.	33.	47.	74.
CAPACITY=	0.	238.	518.	919.	1472.
ELEVATION=	489.	520.	530.	540.	550.

SUMMARY OF DAM SAFETY ANALYSIS

PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	520.00	520.00	530.40
STORAGE	238.	238.	532.
OUTFLOW	0.	0.	2773.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.40	530.37	0.00	530.	2745.	0.00	[illegible]	0.00
.41	530.47	.07	534.	2809.	.17	14.08	0.00
.50	531.23	.83	560.	[illegible]	.67	[illegible]	0.00
1.00	533.09	2.69	627.	10606.	2.00	15.92	0.00

SUMMARY OF DAM SAFETY ANALYSIS

100-YR. FLOOD

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	520.00	520.00	530.40
STORAGE	238.	238.	532.
OUTFLOW	0.	0.	2773.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	526.11	0.00	377.	375.	0.00	13.30	0.00